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AUG 7 - 1964

C & R-PREP.

A Summary of Current Program and  
Preliminary Report of Progress

DECIDUOUS FRUIT AND TREE NUT RESEARCH

of the

United States Department of Agriculture  
and Cooperating Agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

December 1, 1963

## ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research and Service
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton and Tobacco Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research

## ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

### Agricultural Research Service (ARS)

- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite

### Agricultural Marketing Service (AMS)

- 4 - Market Quality
- 4 - Transportation and Facilities

### Economic Research Service (ERS)

- 4,5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Resource Development Economics
- 5 - Economic & Statistical Analysis
- 5 - Foreign Development and Trade Analysis
- 5 - Foreign Analysis Division

### Other Services

- 1 - Soil Conservation Service (SCS)
- 4,5 - Farmer Cooperative Service (FCS)
- 4,5 - Statistical Reporting Service (SRS)
- 6 - Forest Service (FS)



Three organizational unit reports are not reviewed in entirety by any one committee. All of the information in them is included in the subject matter reports.

Agricultural Research Service (ARS)

Agricultural Engineering  
Crops  
Entomology

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

- |  |   |
|--|---|
| 1 - Cross Commodity Research of<br>Agricultural Engineering, Crops,<br>& Entomology Research Divisions | 7 - Cross Specie and Miscellaneous<br>Animal Research |
| 3 - Rural Dwellings  | 8 - Cotton and Cottonseed                             |
| 6 - Forestry (Other than Forest<br>Service )   | 8 - Tobacco   |
| 7 - Beef Cattle  | 9 - Grain and Forage Crops                            |
| 7 - Dairy  | 10 - Citrus & Subtropical Fruit                       |
| 7 - Poultry  | 10 - Deciduous Fruit & Tree Nut                       |
| 7 - Sheep and Wool   | 10 - Potato   |
| 7 - Swine  | 10 - Vegetable  |
|  | 10 - Florist, Nursery & Shade Tree                    |
|  | 11 - Oilseed and Peanut                               |
|  | 11 - Sugar  |

A copy of any of the reports may be requested from Roy Magruder, Office of Administrator, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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## INTRODUCTION

This report deals with research on many kinds of deciduous, small fruits, grape and edible tree nuts. It does not include extensive cross-commodity work, much of it basic in character, which contributes to the solution of problems of other agricultural commodities, as well as those of deciduous fruits and edible tree nuts. The progress on cross-commodity work is found in the organizational unit reports of the several research divisions of the Department.

This report is organized by problem areas which are shown as the major subjects under the three main divisions in the table of contents. For each of the problem areas there is a statement of (1) the Problem, (2) USDA PROGRAM, (3) REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS for the past year and (4) PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH.

Research on deciduous fruit and tree nut problems is supported by (1) Federal funds appropriated to the research agencies of the USDA, (2) Federal and State funds appropriated to the research agencies of the USDA, and (3) private funds for research carried on in private laboratories or for support of State Station or USDA work.

### Research by USDA

#### Farm Research.

Farm research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology and Agricultural Engineering Divisions of the Agricultural Research Service; and in fiscal year 1963 involved about 75 professional man-years.

#### Nutrition, Consumer and Industrial Use Research

Nutrition and consumer use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation and care in homes, eating establishments and institutions. This work is done by the Divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service, and in fiscal year 1963 involved 9.5 professional man-years. Utilization research deals with methods of preservation of these commodities through canning, drying, freezing, or combinations of these methods and also with the origination of new forms of food products or combinations of fruits and nuts with other foods. It is also concerned with improved equipment and processes. The work is done at the Eastern Utilization Research and Development Division, Wyndmoor, Pennsylvania; at the Western Utilization Research and Development Division, Albany, California; at WURDD laboratories at Pasadena, California; and at Puyallup and Prosser, Washington; and under contract with State and foreign country laboratories and in cooperation with the industry and other

## INTRODUCTION (Cont'd)

organizations mentioned under program for each research area. In fiscal year 1963 the work involved 58 professional man-years.

### Marketing and Economic Research

Marketing research involves the physical and biological aspects of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by the Market Quality and Transportation and Facilities Research Divisions of the Agricultural Marketing Service.

Economic research is concerned with market potentials for new products and uses; merchandising and promotion, economics of transportation and storage, marketing costs, margins and efficiency; market structure, practices and competition; information, outlook and rural development; supply, demand and price; situation and outlook; consumer preference; improvement of crop estimating procedures, and improving marketing through research with farmer cooperatives. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Research Divisions of the Economic Research Service; by the Standards and Research Division of the Statistical Reporting Service; and by the Marketing Division of the Farmer Cooperative Service. Approximately 41 professional man-years were devoted to marketing and economic research in fiscal year 1963.

### Interrelationships Among Department, State and Private Research

Much of the Department's research is cooperative with State Experiment Stations, various sectors of industry and with growers. Cooperative work is jointly planned and frequently participated in by Federal, State and industry workers. The nature of the cooperation varies with each study. It is developed to fully utilize the personnel and other resources of the cooperators. There is regular exchange of information between State and Department scientists to assure that the research programs complement each other and eliminate undesirable duplication. Many Department employees are located at State Stations and use laboratories and office space close to, or furnished by, the State.

Privately supported research of considerable extent is done by food processors and distributors, food industry and trade associations, food container and equipment suppliers, marketing equipment and facility manufacturers, chemical and fertilizer companies, package and container manufacturers, market research institutes and corporations, nurserymen, orchardists, and grove owners. Industry's cooperation in supporting research on deciduous fruits and tree nuts in the form of grants, gifts or loans of materials, equipment and facilities at Federal and State stations has contributed greatly to its success.



## INTRODUCTION (Cont.)

A number of food processing companies and wholesale and retail distributors are presently conducting research in various phases of products and process development in frozen, canned, and dried tree fruits and nuts. The canning, freezing, and dehydrating industries each maintain an association with a technical staff and either do research in their own laboratories or support research at USDA laboratories, universities, and other organizations. Allied industries and suppliers to the food processing industry maintain excellent laboratories and large research staffs to provide technical information to the industry.

Marketing equipment and facility manufacturers also make sizeable contributions to research on the development of equipment for handling fruits on the farm or orchard, into and out of packing houses, transportation vehicle, wholesale distribution center and in the retail establishment, as well as research on the containers in which it is moved and on the transportation vehicles from which it moves from one point in the distribution channel to another. Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, market promotion and development, and interregional and inter-market competition.

Chemical and fertilizer companies make a significant contribution in research on the development of new materials or combinations of materials to produce more efficiently, high quality fruits and tree nuts through better nutrition of the growing plant, control of diseases, insects, nematodes, weeds and the regulation of growth processes through use of growth regulator substances such as fruit set thinners, stop-drop chemicals, bloom retarders, etc.

There are a few private breeders of deciduous fruits and tree nuts and a number of the larger nurserymen spend considerable time and money in the search for, and testing of, new varieties in the major production areas; sometimes on their own acreage, but usually in cooperation with some grower. **The contribution of growers to our overall research effort on deciduous fruit and tree nuts is substantial.** Certainly, in the field of production his help is indispensable for most of the laboratory research results must finally be confirmed by orchard scale experiments. The grower cooperates with the U.S.D.A., State Experiment Stations and suppliers of many materials and equipment, usually without compensation except for the experience and knowledge gained.

### Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Early Production from Young Apple Trees. Young Delicious apple trees in commercial orchards are often slow to yield a good crop even after they are big enough to support one. In a 5-year study at Wenatchee, Washington, to determine the best way to bring young apple trees into

## INTRODUCTION (Cont.)

early and profitable production, the effects of nitrogen fertilizer level, pruning, and scoring were studied. If trees remain unpruned for 2 years before and 2 years after the first crop (usually in 4th or 5th year) the yield of young trees increases. The higher yields of the unpruned trees were due to more fruiting buds. Scoring (cutting the bark around the circumference of the trunk to keep the products of photosynthesis in the tree top and stimulate fruit-bud formation) tended to increase fruit set initially, but continued annual scoring tended to reduce tree vigor and fruit set regardless of pruning treatment. Adequate nitrogen--compared with low--increased yields of unpruned but not of pruned trees. Thus adequate nitrogen applied to trees unpruned during early years in the orchard will make early and more profitable production.

New Dried Fruit Preservation Method. High-moisture dried fruits are now extensively preserved with sorbates as the result of cooperative research by Department and California Experiment Station scientists, partially supported by industry funds. In recent years there has been an increased consumer demand for high-moisture products because they are more tender and palatable when eaten out of hand, and can be cooked rapidly without prolonged simmering. Because high-moisture dried fruits are susceptible to mold and yeast spoilage, some type of antimycotic treatment is necessary. Sorbates were found to be highly satisfactory for this purpose and conditions for their use were developed. Sorbates do not evaporate even after the package is opened and are effective until the fruit is eaten. Within two years of discovery, the new treatment achieved widespread acceptance, as indicated by the scale of commercial use. Nearly all high-moisture dried prunes and over 50% of the dried figs for market are now treated with sorbates.

Concentrated apple juice. A commercial installation to produce concentrated apple juice using a process based on EU research is scheduled to begin operation this fall. The factory is now being installed at Cashmere, Washington, by Tree Top, Inc., a growers' cooperative. The new product is a four-fold frozen concentrate with restored aroma. Factory capacity is approximately 3 million bushels of apples annually. It is estimated that apples for the concentrate can yield the grower approximately 50% more than apples used in making the single strength juice currently produced by Tree Top.

Sex attractants--a new approach to insect control. The isolation, identification and synthesis of the powerful sex attractant found in gypsy moth females represents a break-through in research on the development of highly specific methods for insect detection and opens the way for a new desirable approach to insect control. The attractant produced by virgin female American cockroaches has been isolated and identified. Recent research has shown that virgin female adults of



## INTRODUCTION (Cont.)

several major pests, including the European corn borer, house fly, cabbage looper, cotton leafworm, pink bollworm, tobacco hornworm, tobacco budworm, cockroaches, peach tree borer, lesser peach tree borer, and banded cucumber beetle, contain specific sex attractants. Research on methods of isolation and on the chemical composition of the natural attractant substances that is now underway should lead to their future synthesis.

Mechanization of Harvesting and Farm Handling. In cooperation with several State Experiment stations, good progress has been made in mechanizing the harvesting and farm handling of cherries, blueberries, and prunes.

Nondestructive Measurement of Interior Quality of Fruits, Vegetables and other Commodities. Techniques and equipment have been developed for making measurements of the spectrum of light transmitted through intact fruits and vegetables. These measurements have led to the development of methods to measure the maturity of peaches, apples, plums, and other fruits, to detect black-spot of potatoes, water core or other internal disorders of apples, and blood spots in eggs. Methods can be made available whereby the non-conforming specimens are automatically removed from the packaging lines.

Peach Container Family. A "family" of containers for peaches was rounded out by development and evaluation of a low-cost, combination veneer and fiberboard wirebound crate for a bulk pack of fruit in a range of sizes. Other members of the family, previously developed and evaluated, were a film-wrapped pulpboard till which stimulated sales of small peaches, and a shallow fiberboard box with shipping trays which reduced transit damage of large peaches. Package differentiation permits the marketing of peaches in containers that are most suitable for particular sizes or qualities, and that are most popular in particular segments of the consuming market. Completion of this family of containers will enable the peach industry to receive the highest average price for its whole crop.

The professional staff of the Division is much too small to give adequate attention to the problems now being studied and to undertake other new and urgent research represented by pending proposals. Technology is changing rapidly in the physical elements and methods applicable to marketing operations. It is important that the application of new technology be explored before instead of after major investments are made in new plants and equipment, if costly mistakes are to be avoided.



## I. FARM RESEARCH

### CROP INTRODUCTION AND EVALUATION Crops Research Division, ARS

Problem. One of the important needs in a more efficient agriculture is the development of improved planting material with resistance to insects, diseases and climatic hazards; increased adaptation; and higher quality. There is a need to search out, introduce, and evaluate the widest possible genetic base of deciduous fruits and tree nuts from foreign and domestic sources that may be of value as varieties, rootstocks, or breeding materials.

#### USDA PROGRAM

The Department undertakes a continuing program of plant introduction, evaluation and maintenance. The research involves botanists, horticulturists and plant pathologists who are engaged in both basic and applied studies that will provide plant scientists and others with documented germ plasm.

Plant introduction is undertaken in both foreign and domestic fields, either through direct exploration or international exchange. Taxonomic and economic botanical research on world plant resources, development of national inventories of introduced stocks, coordination of foreign and domestic plant collecting, and botanical assessment of the results of crop utilization screening programs are conducted at Beltsville. Cooperative arrangements with the four regional projects provides for domestic explorations.

Preliminary evaluation of deciduous fruit and tree nut stocks is done at Beltsville, Maryland; Glenn Dale, Maryland; Experiment, Georgia; Miami, Florida; Chico, California; Geneva, New York; Ames, Iowa; and Pullman, Washington. It involves observations for specific characters needed in varietal improvement, development of potential new or improved rootstocks, quarantine propagation and indexing for viruses, and the maintenance of collections of important varieties. Regional station pathologists screen the introductions for disease tolerance. Federal, State, and private breeders cooperate in the early evaluation of introductions. Needs for additional breeding stocks are assessed by the research leaders at Beltsville, and become the basis for future plant exploration and introduction.

The Federal scientific effort devoted to research in introduction and evaluation of deciduous fruits and tree nuts is 5.0 professional man-years.



## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Domestic explorations in cooperation with the four regional new crops programs resulted in the following: NE-9, some collecting of wild blueberries; NC-7, the completion of a 3-year exploration program for small fruits in Alaska added 135 new collections for evaluation by breeders in the North Central States; S-9, 142 local fruit and nut varieties from the Gulf States were added to the holding stock of germ plasm at LSU that represents types of unusual hardiness, quality, or similar characteristics;

During the year, 487 new fruit and nut introductions were received, the majority of which required a quarantine period at Glenn Dale, Maryland. Seventy-four introductions were offered to Federal and State experiment stations. Virus indexing in quarantine remains the governing factor in the distribution of introduced stone fruits. This year, 39 introductions were included in the indexing program and 16 varieties were released as virus negative from the Glenn Dale, Maryland, Plant Introduction Station.

Research at Chico, California, on Actinidia chinensis (Chinese gooseberry) is directed to seed germination, fertility, crop yield, and ripening. Preliminary studies show that alternating cold and warm temperatures during stratification may increase germination, and that for the one variety grown in sufficient quantity, heavy crops are produced in alternate years but does not imply distinct alternate bearing as is customary for apples. Despite intensive soil fumigation, losses in establishing actinidia seedlings reach about 30% and indicate the need for research on improved soil fumigation techniques in relation to this crop.

Emphasis with stone fruits such as almond, apricot, cherry, peach and plum at Chico, California, is on evaluation of seedling progenies of desirable introductions and the compilation of descriptive catalogs of introductions. For example, seedling populations of the early ripening plum, P.I. 94232 (Persia), and the heavy-bearing plum-cot, P.I. 117682 (USSR) 'Black Alexander,' are now in nursery blocks for observation for outstanding fruiting characteristics. Descriptions pertaining to all plum introductions in the Chico collection have been completed and will be distributed to interested researchers.

As a result of detailed observations on 134 apple introductions, a descriptive catalog of early ripening apples has been prepared at Glenn Dale, Md. One such variety, P.I. 143973 (Manitoba, Canada) 'Red Apple,' ripens as early as July 30 and is of high quality. The bright red skin color imparts an attractive pink color to the fruit sauce. This apple was discarded in Western Canada since it was not suited to the climate but appears desirable under our conditions and several experiment stations have expressed interest.



Seedlings of P.I. 182831 (Maryland), *Malus* 'Niewland,' have been uniformly dwarf at Glenn Dale as compared to progenies of 9 other parents. This suggests the possibility of developing dwarfing stocks which might not transmit viruses owing to their seedling origin, as opposed to vegetatively produced dwarfing stocks. Influence of this seedling line on growth and vigor of scion varieties must yet be determined.

Observations of leaf-spot resistant seedlings of cherry introductions, P.I. 186943 and 202119 (originally from Germany under nos. 127413 and 132028), showed that the resistance to artificial inoculation in 1961 was repeated in the field in 1962 when the plants were subjected to natural infection. Limited progenies of P.I. 202119 showed no natural infection while a population of 218 seedlings of P.I. 186943 had a low incidence of natural leaf-spot infection.

Although the regional cooperative programs are not engaged in extensive evaluation of fruits and nuts, the Geneva Introduction Station reported that a strawberry introduction, 'Senga Sengana,' P.I. 264680 (Germany), is highly productive with large fruits which maintain size throughout the season. It ripens in mid-season and appears most promising in the northern fringe of the producing areas.

The survey of fruit and nut clones in the U. S. requested by the National Coordinating Committee for New Crops is being prepared in 3 parts. The first part which deals with apples consists of approximately 5,509 entries. It was completed and will be available for distribution in 1963. Part 2 of the survey dealing with stone fruits is two-thirds completed. Approximately 5,848 items are covered in this part. The 3rd part of the survey covers pears, nuts and miscellaneous fruits such as small fruits, subtropical fruits, etc. This part consists of about 5,565 items.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE PROGRAMS

Fisher, H. H. 1963. Survey of fruit and nut clones in the U. S. Proc. Northern Nut Growers Assn. 53.

Whitehouse, W. E., J. L. Creech, and G. A. Seaton. 1963. 'Bradford' Ornamental pear - a promising shade tree. American Nurseryman. April 15.

TREE FRUIT CULTURE, BREEDING AND GENETICS,  
DISEASES AND VARIETY EVALUATION  
Crops Research Division, ARS

Problem. Since stone fruits are widely grown throughout the United States and since the important commercial areas vary greatly in soil and climatic conditions, the research problems are variable. More research is needed on the reaction of varieties in different producing areas; breeding for improved qualities needed in different areas including the ripening at variable periods from the early to the late marketing seasons; basic information and control methods of disease organisms including virus diseases; development of hardy disease and nematode-resistant rootstocks; effects of climate on growth, yield, and fruit qualities; replanting of peaches in old orchard locations; thinning fruit with chemical sprays for improvement in quality and size; and chemical relation of nutrition to fruit quality in the different growing areas.

Apple and pear production is limited by the high cost of growing practices and lack of basic information on nutrition, rootstocks, basic physiology of growth, and disease control. In eastern United States, up to ten cover sprays are required to control diseases that reduce the foliage and scar the fruit. There is need for new rootstocks that will bring apples and pears into production earlier, will produce smaller trees with greater bearing surface and more light exposure, are not virus sensitive, and are winter hardy and disease resistant. Basic information is needed on the cause of apple bitter pit and other internal fruit disorders that initiate in the field. More precise information is needed on the basic physiology of fruit setting, fruit thinning, and growth physiology. New high-quality, early-maturing varieties are needed for the South and better dual-purpose varieties for the fresh fruit and processing industries in northern areas.

USDA PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, plant physiologists, and horticulturists engaged in both basic studies and the application of known scientific principles to the solution of fruit growers' problems. Apple breeding research at Lafayette, Indiana, and at Madison, Wisconsin, and cultural and disease research at Wenatchee, Washington is cooperative with the respective State Experiment Stations as in pear research at Hood River, Oregon, and

Riverside, California. Peach breeding and varietal evaluation research at Fresno, California, is in cooperation with Fresno State College and at Prosser with the Washington Agricultural Experiment Station; disease research at Clemson is cooperative with the South Carolina Agricultural Experimental Station, and at Riverside in cooperation with the California Citrus Experiment Station. Plum breeding and evaluation research at Fresno is cooperative with Fresno State College and at Prosser with the Washington Agricultural Experiment Station. Cherry breeding and evaluation research at Prosser is cooperative with the Washington Agricultural Experiment Station; and disease research at Logan is cooperative with the Utah Agricultural Experiment Station. Apricot breeding research at Fresno is cooperative with Fresno State College.

Federal stations having deciduous fruit-tree research are Wenatchee, Washington; Fort Valley, Georgia; Mandan, North Dakota; and Beltsville, Maryland. Research at Wenatchee includes variety evaluation of pears; disease research with pear, peach, plum, and cherry; and cultural research with apple and pear. Breeding, variety evaluation, and cultural research is done with peach at Fort Valley, and with apple at Mandan. Research at Beltsville includes breeding and genetic studies of apple, pear, and peach; diseases of apple, pear, and peach; varietal evaluation of peach; and cultural studies of apple and peach.

The Federal scientific effort devoted to research in this area totals 22 professional man-years. Of this number 4.9 is devoted to breeding and genetics; 10.8 to diseases; 1.4 to variety evaluation; 4.5 to culture; and 0.4 to program leadership.

Six 5-year P.L. 480 contracts are currently in effect: (1) with the Instituto Biologico, Sao Paulo, Brazil, for studies on basic research on the biochemistry of crown-gall formation (S3-CR-9), providing funds with a \$24,033 equivalent of Brazilian cruzieros, and having a projected duration from 1961 to 1966; (2) with the Israel Ministry of Agriculture for studies on the physiology of rest (dormancy) and its application to fruit growing (A10-CR-8), providing funds with an \$83,350 equivalent of Israeli pounds and having a projected duration from 1960 to 1965; (3) with the Department of Plant Pathology, University of Milan, Italy, for studies on the etiology and methods of controlling pear Moria disorder (pear decline) in Italy (E15-CR-7), providing funds with a \$61,333 equivalent in Italian lire and having a projected duration from 1962 to 1967; (4) with the Department of Fruit Breeding, Research Institute of Pomology, Skierniewice, Poland for studies on evaluation of East-European and Asiatic fruit



species and varieties recently introduced into Poland which are of value to the U. S. (E21-CR-6), providing funds with a \$24,690 equivalent in Polish zlotys and with a projected duration from 1960 to 1965; (5) with the Plant Physiology Laboratory, Research Institute of Pomology, Skierniewice, Poland, for studies on growth promoting substances and inhibitors in apple trees during different stages of its development (E21-CR-7); providing funds with a \$13,295 equivalent in Polish zlotys and with a projected duration from 1960 to 1965; and (6) with the Laboratory of Plant Pathology, Institute of Pomology, Skierniewice, Poland for studies on the epidemiology and control of apple scab (E21-CR-8), with funds providing a \$9918 equivalent in Polish zlotys and with a projected duration from 1960 to 1965.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Breeding

1. Apple. The development of varieties resistant to the apple scab organism (Venturia inaequalis) continues at Lafayette, Indiana and Madison, Wisconsin. Approximately 2000 seedlings were fruited at Lafayette. Six selections of these have commercial potential while 64 others are retained for further testing and possible use as parents. It has been shown at Madison that wild-type lines of the fungus show different nutritional responses to amino acids. Preliminary results from serological studies with fungus lines and host varieties have indicated that there may be correlation between antigenic properties and host specificities.

Four seedlings with highly-colored fruits have been selected at Mandan, N. D. as a result of the breeding program to develop cold-hardy and drought-resistant varieties for the northern plains. These and 9 other selections have been planted for further testing.

2. Pear. Because the severity of fire blight (Erwinia amylovora) prevents extensive commercial pear plantings in many areas of the country that are otherwise well suited to pear production, increased emphasis is being placed on the pear breeding program. At Beltsville, a 15-acre site has been cleared of forest to provide room for a variety collection and a seedling planting for genetic studies.

In 1962, 8720 seed were produced from 138 controlled crosses. A total of 1910 seedlings from the 1961 crosses have been planted for genetic studies. A total of 3117 additional seedlings have been retained in the nursery where they will be artificially inoculated with fire blight.

At Mandan, N. D. crosses between hardy varieties and high quality, blight resistant varieties from Beltsville resulted in about 2200 seeds.

3. Peach. At Fort Valley, Georgia emphasis again was on development of early-ripening low-chilling varieties. In 1962, approximately 3000 seedlings were fruited and 56 selections were propagated for second-test planting. Two selections were named and released for general propagation. Suwanee is a large, attractive freestone ripening about 10 days after the beginning of Maygold season, has a chilling requirement of approximately 650 hours, and should be of value in areas where Maygold is grown. Dixiland ripens 2 or 3 days ahead of Elberta. The fruit is ovate, large sized and freestone. The chilling requirement is also about 650 hours. Dixiland is recommended for trial in areas where Southland can be grown.

At Prosser, Washington, emphasis is on bud-hardy, high-quality, firm varieties adapted both to the fresh-market and to processing. In 1962, of about 1000 seedlings fruited for the first time, 5 were propagated for second-testing. Three selections from crosses planted in 1950 have performed well in second-test and adaptation trials in the Pacific Northwest and are under consideration for release. Two appear to have good bud hardiness. A few promising peach and nectarine selections from crosses planted in 1955 and 1957 are propagated for second testing. All selections in advanced testing stages were evaluated for pollination-compatibility. Two appeared partially self-sterile.

At Beltsville, bacterial spot resistance and mid-season or late ripening varieties of high quality are sought. Of about 8225 seedlings fruiting for the first time, 11 were selected for second-testing.

At Fresno, California, development of firm yellow-fleshed high-quality varieties for mid-season and later were emphasized. Approximately 130 peach and nectarine selections, some of which have fruited several times, were saved for further observation. One selection ripening the second week of September has performed well in commercial trials and is considered ready for introduction.

Since its maturity season may overlap that of another selection, which is more highly colored but has fruited only twice, further observation is necessary. Two peach and two nectarine selections are being tested commercially. Six low-chilling peach selections, of marketable quality are being tested in Southern California and Florida. Poor pollination in 1961 reduced the number of seedlings planted out to 700.

4. Plum. At Mandan, crosses were made between varieties of P. salicina, P. salicina hybrids, and native varieties, in an attempt to combine the better quality of Japanese plums with the winter hardiness, drought resistance and late blooming character of native plums. Five selections were made, including three hardy P. domestica types which may be useful as parents in future crosses. Screening for hardiness and other desirable qualities was continued with varieties and selections in the variety tests. Increased emphasis was placed on prune-type selections with hardiness and drought resistance for the Great Plains.

At Prosser, improved plums of early Italian Prune type are sought. None of the selections made are considered to have commercial possibilities. More emphasis on plum improvement has been reflected in expanded plum crosses in 1961 and 1962. The new Edwards and President varieties, and several selections from the Vineland, Ontario station were the main parents used.

At Fresno, breeding for superior Japanese-type plums is emphasized. Twenty-seven selections were saved for second-testing. Two new selections and four others which will fruit in commercial trials in 1963 are outstanding. Fifteen hundred seedlings were planted in 1962 and the usual number of cross-pollinations were made.

5. Cherry. In further screening of selections at Prosser it appeared one 'white' selection has commercial promise as a companion variety to Rainier and that a Bing-season selection is larger-fruited than Bing and should be tested as a possible replacement for Bing. Both were propagated for semi-commercial tests. A dark selection almost two weeks earlier than Bing apparently was freed of virus by heat treatment and will be reevaluated. Four selections from seedlings planted in 1958 are being propagated for testing. Routine artificial hardiness tests of promising selections were continued. Processing tests of six promising selections and Chinook and Rainier in comparison to Bing were made in cooperation with the Western Utilization Laboratory at Prosser.



At Mandan, selection and screening continued with P. cerasus, P. tomentosa and P. japonica cherries. Improved size and quality are sought while retaining the hardiness and other requisites of cherries for the Great Plains. At Cheyenne, about 3000 European plum, 2500 peach and several Prunus tomentosa and interspecific cherry seedlings are being maintained but have not fruited. Two hardy peach chance seedlings were distributed to northern and western breeders. Variety plantings have been reduced to hardy P. domnestica and P. insititia plums and varietal comparisons published.

6. Apricot. At Prosser, a selection combining the bright waxy appearance and hardiness of Sun-Glo with the larger size of Perfection has been propagated for semi-commercial trial as well as being used for hybridization. All pollen parents used were compatible with the selection. Some high-quality but smaller selections from Earliril parentage are being second-tested.

At Fresno, selection for resistance to pit-burning in combination with large size and high quality is done. Thirty-three selections were saved for further testing. A selection resembling Perfection but ripening 10 days before Newcastle (the earliest commercial variety) is promising. Two selections mentioned in previous reports withstood 105 degrees without pit-burning. Twelve hundred seedlings were planted in 1962. The usual number of cross pollinations were made.

At the Southern Great Plains Field Station, Woodward, Oklahoma, 15 apricot seedlings selected from shelterbelt plantings in 1943 have been evaluated over a 14-year fruiting period. Some crop has been produced in 7 of the 14 years. One relatively late-blooming and 5 other bud-hardy selection show promise for use as parents in apricot crosses. Others, somewhat less hardy but larger-fruited may have promise as parents for commercial producing areas.

## B. Diseases

1. Apple. Powdery mildew. Preliminary greenhouse studies at Beltsville indicate manganese-bis-nitrophenyl-dithiocarbamate controls powdery mildew (Podosphaera leucotricha) on potted apple seedlings as well or better than standard Karathane. These tests indicate this material has good eradicant properties which might make it quite useful under field conditions. Field tests on apples are planned for the 1963 season.

Field spray tests in Oregon on Newtown apples show that 8 applications of Cyprex plus Karathane applied every 7-10 days gave more effective control of powdery mildew than 3 applications applied every 14-20 days. When used on a 8-application schedule no significant difference was found between low (1/4 lb./100 gal.) and high (1/2 lb./100 gal.) fungicide concentrations. The 1/2 lb./ 100 gal. dosage applied 3 times during the season, although better than the check, gave significantly poorer control than the 1/4 lb. and 1/2 lb. level applied 8 times.

One-acre blocks of Newtown apple trees were also used to compare dusting versus spraying of Cyprex plus Karathane for control of powdery mildew. Dust compared favorably with sprays on both a 7-day and 14-day schedule. The 7-day schedule, however, resulted in better control of terminal infection than did the 14-day schedule.

Apple scab. Research to study apple scab is sponsored by the United States, in Poland, under provisions of P.L. 480 Project entitled epiphytology of apple scab. Continued studies, started in 1960, showed (1) the maturation of ascospores is dependent upon temperature and in 1962 the spores were ready for dissemination 2 to 3 weeks prior to the swelling of apple buds; (2) the intensity of apple scab infestation in any given year depends primarily on the amount of rainfall in April and May; (3) dodine, used either in a protective or eradicant program, was the most effective fungicide tested; and (4) that viable conidia can be disseminated in small water droplets for short distances.

Stem pitting virus. In field plots at Logan and North Ogden, Utah, poor growth of several apple varieties and winter hardy body stocks is attributed to virus infection. Data obtained indicates stem pitting virus appears responsible for a reduction in rate of growth, vigor, and yields of apple trees. Stem pitting symptoms could be recognized only in trees on Virginia Crab body stocks or in Red Delicious variety on other stocks. Growth of trees on Hibernial Crab was also generally poor but indexing for stem pitting is necessary where this stock is involved. Greenhouse experiments indicate that other latent viruses such as Spy 227 lethal and chlorotic leaf spot may also be involved in causing poor growth of some trees. Different apple varieties vary in their susceptibility or tolerance to latent apple viruses.

Trunk twisting and flattening virus. Excessive twisting and flattening of trunks and large limbs of apples growing on dwarfing rootstocks has been of recent concern to growers and nurserymen in



some north-central states. A similar type of trunk twisting and flattening was obtained on experimental trees at Wenatchee, Washington, during 1962. The trees involved were crab varieties such as Hyslop, Niewland, and Platycarpa that had received inoculum from 10 different sources. Two viruses (chlorotic leaf spot and stem pitting) were considered to be common contaminants of all 10 sources of inoculum. The trunk twisting and flattening was caused by a virus transmitted to the test trees by the inoculum employed. Whether the virus concerned is stem pitting or some related virus as suspected has not been determined. A similarly-described disorder was found at Beltsville in 1962 on 250 trees of the varieties McIntosh, Jonathan, Red Delicious, and Golden Delicious grafted on Malling #7 semi-dwarfing rootstock.

Miscellaneous viruses. Two unidentified viruses obtained from apple were mechanically transmitted to herbaceous hosts, from which purified virus preparations have been made. One virus, recovered from an apple mosaic culture, is similar to Tulare apple mosaic virus. An unidentified virus recovered from the inner bark of apple trees that show stem pitting symptoms can be carried in lettuce and produce local lesions on Gomphrena globosa and Chenopodium amaranticolor. This virus was transmitted to Hopa crab seedlings and induced necrotic and chlorotic leaf patterns. The virus was recovered in low titre from leaf tissue of Malus platycarpa with symptoms of chlorotic leaf spot.

2. Pear. Fire blight. During 1962 fire blight was serious in many parts of the country. At Beltsville it caused considerable damage on pears and apples for the third consecutive year and considerable infection appeared for the first time in a 3-year-old semi-dwarf block of Jonathan apples planted 1/3 to 1/2 mile distant from other fruit trees. Preliminary greenhouse and field studies suggest that infection on these trees may be from non-virulent strains of Erwinia amylovora which have suddenly turned virulent. The appearance of natural fire blight infection on resistant Magness pear trees in the field during the last two years suggests the natural development of more virulent strains of E. amylovora. However, greenhouse studies failed to demonstrate any difference in virulence of isolates from resistant Magness and susceptible Bartlett pears suggesting the same strain of organism is causing infection on both varieties in the field.

Research indicated some of the resistance shown by Magness pear may be due to oxidation products, possibly polyphenols, which inhibit growth of E. amylovora. It is believed that these products are produced when the plant tissues are injured.

Apparently Magness pear tissues produce more of these materials than Bartlett thus accounting for Magness' being more resistant. Tests indicate decreased inhibition when the oxidation products are reduced by antioxidants. An attempt will be made to isolate and identify such products.

Pear decline. Pear decline continues to be a very serious problem in the pear growing areas of the west coast. At Wenatchee, Wash., 55 percent of 1-year-old trees (in tubs) that were on Pyrus serotina rootstocks died of quick decline after they had been subjected to pear psylla feedings for 6 weeks. Only 35 percent of the control trees that were kept free of psylla died of the disorder. Observations will be continued in order to determine any additional effects.

The phloem damage of the petioles of 11 rootstock varieties of pears (comprising 5 species) was determined after the trees were subjected to controlled psylla feedings. The extent of phloem damage generally correlated with the susceptibility of rootstocks to pear decline under field conditions, and this technique should prove valuable in evaluating pear rootstocks for future plantings.

In pear psylla studies, the use of radioactive carbon ( $C^{14}$ ) has shown that psylla previously fed on pear leaves in a  $C^{14}O_2$  atmosphere inject traceable amounts of  $C^{14}$  metabolite into the vascular system of plants. Autoradiograms have shown that this  $C^{14}$  metabolite is transported to terminal leaves. Other psylla were labeled with radioactive phosphorous ( $P^{32}$ ), but there was no indication from autoradiograms that the  $P^{32}$  compounds from the psylla entered the plants.

Biochemical analysis of pear-psylla water extracts have shown that these insects have high levels of adenine and guanine containing compounds. Preliminary studies have shown that water extracts from pear psylla cause an increase oxygen uptake of mitochondrial preparations from P. communis leaf tissue.

At Riverside, California, 54 attempts were made to transmit pear decline through bud grafts, with the result that during 1962 one positive and 15 possible transmissions were obtained. Twenty additional varieties of woody species were tested as possible indicators of pear decline without success. In Washington, no decline occurred on 480 pear trees receiving spur graft inoculum which were held an additional year under greenhouse conditions.



At the end of the second growing season, 68 percent of a field planting of 149 Bartlett trees on P. ussuriensis roots had collapsed or seriously declined. Eighty comparable Bartlett trees on P. communis roots had 5 percent showing distress comparable to a moderate decline condition. No transmission tests had been conducted on these trees and undetermined factors other than cultural are considered responsible for the declining condition. No tests in Washington have produced evidence of a graft transmissible virus as the primary cause of pear decline. Research to study pear decline is sponsored by the United States under provisions of P.L. 480 Project E15-CR-7 entitled etiology and methods of controlling pear Moria disorder (pear decline) in Italy. Systematic experiments were initiated during 1962 to determine the interrelationships of the pear psylla insect, rootstocks, and cultural conditions with the disorder. Results of initial tests to determine the relative susceptibility of different stocks to psylla toxin were inconclusive. The potential role of nematodes, root-rot fungi, and viruses, particularly, as causes of the disorder are being thoroughly tested but results of such studies are not yet available.

Pear scab. In Oregon, Bartlett pear trees having a high incidence of pear fruit scab (Venturia pyrina) were sprayed with several fungicides to test their effectiveness for disease control under epiphytotic conditions. Only Cyprex (1 lb./100 gal.) and a new dithiocarbamate compound resulted in substantial reduction of scab at harvest time.

Pear blister. During 1962 positive evidence of transmission was obtained from one source of pear blister disease. Considerable necrotic bark blisters occur on growth older than current seasons growth and there is some evidence of reduced vigor of affected trees. No fruit symptoms have been observed.

3. Peach. Root- and crown-rot. Additional studies with strains of Pythium ultimum and P. irregulare in a controlled-atmosphere greenhouse (65-75°F) have demonstrated variable pathogenicity of these organisms on peach seedlings.

Bacterial canker. Tree losses in the southeast due to bacterial canker and/or winter injury were less numerous in North and South Carolina than in recent years. However, considerable losses were experienced in Georgia and Alabama, apparently due to a combination of winter injury and bacterial canker. This combination presented a confusing symptomatology which made it very difficult to distinguish between the two disorders. The possibility that winter injury or cold

damage predisposes peach trees to invasion by bacterial canker is being investigated.

Artificial inoculation of peach trees under controlled environmental conditions has produced characteristic cankers 3 to 4 inches long, but wholesale destruction of plants as observed in the orchard has not been achieved experimentally. Similarity in results obtained with California isolates of Pseudomonas syringae, ATCC cultures of Ps. syringae, and isolates from South Carolina indicate that bacteria of this type are causing the difficulty in the southeast.

A pruning experiment was initiated in September, 1962, to determine (1) if bacterial canker can be spread by pruning, and (2) if the time of pruning causes a variation in the severity of bacterial canker. Sterilized pruning shears (1 minute in 10% clorox) and infested shears (dipped in a water suspension of Ps. syringae between cuts) were used for pruning trees at 2 week intervals. To date, only minor differences in the visible amount of canker present has been noted. Continuing observations will be made during spring growth to assess the progress and severity of canker.

A study of the bacterial population of peach buds from an orchard showing severe damage from bacterial canker and from a "healthy" orchard of the same age and variety has resulted in relatively few isolations of Ps. syringae-type organisms. With the exception of one culture, all such organisms have been isolated from the diseased orchard. This study will continue throughout the year.

Bacterial leaf spot. Five compounds (diammonium ethylene bis dithiocarbamate, N,N-dimethyl carbamyl N,N-dimethyl thio carbamyl disulfide, triphenyltin acetate, zinc salt of polyethylene thiuram disulfide, and an emulsifiable liquid copper) showed considerable activity in laboratory tests against Xanthomonas pruni. These compounds will be studied further in both greenhouse and field tests.

Several unsuccessful attempts were made during the summer to artificially inoculate field-grown peach trees. This failure apparently was due to adverse environmental conditions because trees which are normally severely diseased failed to show infection during the 1962 season.

Continued greenhouse studies with X. pruni bacteriophage suggest that bacterial leaf spot of peach can be controlled with centrifuged phage as well as with Seitz filtered phage. Because the former method is faster and handles larger volumes than the latter we will



be capable of conducting more extensive tests in the future. It, furthermore, has been found that phage can be concentrated by processing it through an agar column which will expedite evaluation and research.

Peach mosaic. The 1962 Federal-State-County cooperative inspection of southern California peach orchards for peach mosaic revealed 442 infected trees (0.42 percent), slightly more than double the 0.20 percent infected trees found in the quarantine area during 1961. This is the second highest incidence of the disease in the area since 1940. Foliation and defoliation schedules of pear trees were affected following inoculation with budwood from peach mosaic-infected peach trees. However, the virus has not yet been recovered from pear back to peach, and factors responsible for the disturbance remain undetermined.

In Washington County, Utah, there was a large increase in mosaic infected peach trees found during 1962. However, it was considered probable that many of the trees found in 1962 may have been missed during 1961 because of heavy aphid infestation. Peach mosaic was considered to have been eradicated in this area until 1961 when surveys were resumed after a period of several years.

4. Sweet cherry. X-disease virus. In Utah, x-disease continues to be of major importance to peach and cherry growers. Natural spread has been rapid in sweet cherry orchards located in the counties of Utah, Davis, Weber and Box Elder, where productiveness in the most severely affected orchards has been virtually destroyed 3 to 6 years following discovery of the first infected trees. In southern California x-disease infected peach trees have been found for the second year. Infected trees have been removed and the disease is not yet economically important. In Washington the disease is no longer of economic importance in the major peach and cherry growing districts where insect vectors are generally effectively controlled by chemical sprays. During 1962 newly infected peach trees were found in small numbers in a few Washington peach orchards, indicating that the potential for infection and spread of the disease still exists.

In Utah, controlling the disease by removing infected cherry trees has not proved successful. This is attributed in part to the inability to inspect and positively identify infected cherry trees when growing on mazzard rootstock until about 2 years following infection. Other reasons for unsuccessful control are (1) numerous infected choke-cherries growing relatively near commercial orchards furnish a backlog of diseased plants and viruliferous insect vectors, and (2)

the inability to effectively control insect vectors in the orchards or those that may move in from infected native vegetation. Cherry trees propagated in the conventional manner with a single shoot on mahaleb or mazzard rootstock are not recommended for planting in most areas of northern Utah. Varieties top-worked on mahaleb framework currently offers the most promising means of producing cherries where x-disease is a limiting factor, and when so handled no experimental trees have yet been lost because of x-disease virus infection.

Results of tests in both Utah and Washington show that the sweet cherry varieties Long Stem Bing and Dicke Braun Blakenburger have considerable resistance to x-disease virus. While it is doubtful that either of these varieties have qualities requisite for large scale commercial production, they should be useful as breeding stock. Tests in Utah show that the promising recently introduced sweet cherry varieties Rainier and Chinook and 5 other numbered but as yet unnamed selections had no resistance to x-disease virus. Dicke Braun Blakenburger on mahaleb stock did not develop wilt, either in single shoot or when top-worked on mahaleb branches, although infected branches did develop some red-leaf symptoms.

In Washington further results from tests with different strains of x-disease virus show that chokecherries will develop relatively deep red foliage coloration if infected with a strain of the virus that induces relatively mild symptoms on peach; and that a strain very severely affecting peach will induce relatively light pinkish-red and yellow foliage in chokecherry. Results obtained in 1962 also show that both so-called mild and severe strains of x-disease virus could be recovered from sweet cherry on mahaleb roots when inoculated back to peach.

Little cherry. Little cherry is one of the most serious virus diseases of sweet cherry. It has been found widely distributed in flowering cherries and is symptomless in these hosts. Kwanzan and Shiro-fugen flowering cherries have long been employed as important research tools in index testing for certain latent type viruses commonly carried by many species of stone fruits. Results show that presence or absence of little cherry virus in these flowering cherry varieties does not influence the reactions induced in them by the latent type viruses common in stone fruits. Results of tests with a number of flowering cherry varieties show that Gyoiko, Ukon and Washino-O are about equal to Kwanzan as index test plants for green ring mottle virus. No flowering cherry variety has yet been found equivalent to Shiro-fugen as an index test plant for detecting ringspot sour cherry yellows type viruses. Peach, apricot,



chokecherry and Italian prune have been found to be immune to the little cherry virus. All sweet and sour cherry varieties tested will carry little cherry virus. Sour and Duke cherries, when infected with virus, express relatively poor fruit symptoms that are difficult and sometimes impossible to accurately diagnose. In general, the later ripening type of sweet cherry with large dark colored fruits such as Lambert, Bing, Van or Sam, will express better fruit symptoms than earlier dark colored varieties such as Black Tartarian, or any of the light colored varieties such as Napoleon.

Necrotic rusty mottle. In Washington, working with a moderate strain of the virus from which other virus entities had been removed, field-test trees of Dicke Braun Blakenburger, Burbank, Lyons and Esperen, failed to express symptoms 2 years following inoculation. In Utah, a severe strain of necrotic rusty mottle did not induce symptoms in Lyons and Dicke Braun Blakenburger the first year following infection, but mild symptoms developed the second year. Burbank continued to be symptomless 2 years after infection. Natural spread has occurred in experimental plots in both Washington and Utah although the means of natural spread is unknown. In Utah natural spread first occurred in 1962 to check trees near or adjacent to trees that were inoculated in 1957 and 1958.

Utah Dixie rusty mottle and asteroid spot. In Washington County, Utah, this virus disease has continued to spread slowly through sweet cherry orchards. No natural spread has occurred in peach plantings 6 years after young virus-free trees were planted. All trees in some peach orchards are diseased as a result of propagation from infected clones. Attempts to find naturally infected desert-almond plants, Prunus fasciculata, have not been successful, although desert almond is quite commonly found adjacent to orchards in which diseased trees are found. Greenhouse experiments have shown that P. fasciculata can be infected and recognizable symptoms are not produced.

Cherry rough fruit. This disease was previously reported in Utah as an unknown disorder when a number of sweet cherry selections from Iran top-worked on Van resulted in malformed fruits, bumpy and rough, being produced on the Van. This disorder has now been transmitted from affected to known healthy plants in field experiments. Symptoms have been recognized in the fruits that developed only on inoculated branches 2 years after inoculations. While fruit symptoms were somewhat variable in 1962, they were generally mild on small fruited and white fruited sweet cherry selections and most severe on large dark fruited varieties such as Van.



5. Sour cherry. Sour cherry yellows, necrotic ringspot, prune dwarf complex. Research on stone fruit virus diseases at Madison and Sturgeon Bay, Wisconsin, emphasized studies on viruses found associated with the sour cherry yellows, necrotic ringspot, and prune dwarf complex in sour cherries. Fourteen prune dwarf isolates transmitted from herbaceous hosts to Montmorency sour cherry have failed to produce sour cherry yellows symptoms which is significant from the standpoint of the separation of prune dwarf from the complex. An apparently new virus not previously described, and referred to as Italian prune chlorotic ringspot, has been transmitted to a number of stone fruit hosts and has produced diagnostic symptoms in sour cherry, sweet cherry, peach seedlings, Italian prune, Abundance and Burbank plums, chokecherry, and the flowering cherry varieties Kwanzan and Shiro-fugen. The virus was transmitted mechanically from young peach leaves to certain varieties of Petunia hybrida and has a wide host range in the Solanum family and can infect some plants in other families.

In seed transmission studies, certain virus separation was obtained in seedlings grown from seed taken from a Montmorency sour cherry infected with the complex of necrotic ringspot, recurrent necrotic ringspot, sour cherry yellows, prune dwarf, and Italian prune necrotic ringspot viruses. All transmitted through the seed in different proportions except Italian prune chlorotic ringspot virus.

During 1962 there was evidence of continued spread of necrotic ringspot virus in Montmorency orchards in Door County, Wisconsin, which resulted in considerable crop loss. Yield records taken on 15 sample trees with shock ringspot symptoms in 1962 had a yield reduction of 44 percent compared with 1961. At Egg Harbor, Wisconsin, studies have continued on the effect of necrotic ringspot virus infection on yield of some 295 Montmorency sour cherry trees. Seventy-eight new infections occurred in 1962 as compared to 49 in 1961, 20 in 1960, none in 1959, and 2 in 1958. In 1962, 93 healthy trees of the original planting had the same yield average as in 1961, but trees that showed necrotic ringspot symptoms for the first time in 1962 had a yield reduction of 61 percent. Considerable yield variations occur following the year when trees express shock ringspot symptoms and subsequent yields on such trees are likely to be reduced when compared to healthy trees.

6. Miscellaneous. At Riverside, California, long term experiments with pustular canker of Tragedy prune indicates that the disorder is a nontransmissible, bud-perpetuated genetic abnormality. A

series of cross transmission tests show that *Prunus* and *Citrus* species are not affected by viruses common to each other. An isolate of *Prunus* recurrent ringspot virus failed to show recurrence on 43 of 68 apricot varieties tested. In Utah, attempts to infect sweet and sour cherry and *P. fasciculata* with apricot pucker leaf virus were unsuccessful. *P. tomentosa* can be readily infected. Leaf symptoms of apricot pucker leaf in apricot are similar to those produced by peach mosaic in some apricot varieties, but infected peaches show only occasional mild leaf symptoms.

7. General. Screening hosts used for separating virus mixtures. Latent and inapparent viruses commonly occur as contaminants to most cherry virus diseases and frequently cause difficulty in host range studies. These latents can sometimes be screened from virus mixtures by the use of certain resistant stone fruit hosts. In Washington, standard budding and inoculating procedures were used on experimental trees in the field to isolate rusty mottle, necrotic rusty mottle, mottle leaf, green ring mottle, twisted leaf and western x virus cultures from virus mixtures naturally occurring in orchard trees. The screening hosts successfully employed were wild black cherry, chokecherry, apricot, Shiro-fugen flowering cherry and Burbank plum.

Chemotherapy studies. The purification of a virus is essential to understand the modifications that occur in a virus protein as a result of a chemotheraputant reaction. Stone fruit necrotic ringspot has never been sufficiently purified for an accurate study of chemotheraputant effect upon the virus. Necrotic ringspot may be adsorbed to one or more normal plant components in purification since active virus is recovered with equivalent densities of 1.142 and 1.190. Active virus can be recovered after passage through 10 millimicron filters, which indicate an extremely small active unit. Characteristics determined for prune dwarf and line pattern viruses, as well as a number of ringspot virus strains, indicate these are a group of extremely small-sized viruses.

Sixteen antibiotics, one of which has 9 synthesized derivatives, have been processed for antiviral effect on stone fruit necrotic ringspot virus. Five of the antibiotics inhibit primary symptom expression in treated plants but have little or no effect on the synthesis of the virus and inhibit ringspot virus synthesis besides inhibiting primary symptom expression.



Public Law 480 Research. Basic research on the biochemistry of crown gall formation is sponsored by the United States, in Brazil, under provisions of P.L. 480 project S3-CR-9 and initiated in 1961. In this research a polymerized indolic film, oxidatively formed on the surface of aqueous solutions of auxin (IAA) and called deuteriauxin by the researcher, was studied for biological activity. An intensive investigation of the variable response of oat coleoptiles to the active fraction of the film led to the proposal of a new theory about the mechanism of cell-wall elongation based on the physiochemical properties of deuteriauxin.

### C. Varietal Evaluation

1. Apple. At Wenatchee, 32 red bud sports of Delicious fruited sufficiently in 1962 to make quantitative color comparisons. Starkrimson, Red Prince, Top Red, Ryan, and Hi-Early were among those developing the greatest quantity of color. Red Spur, Red King, Wellspur, and Royal Red were intermediate; while Hi-Red, Earlired, Woods, and Paynter had no better color than Starking or Richared.

Cumulative storage tests indicate that the newly introduced USDA (Mandan, N.D.) varieties Killand, Peach Garden, and Thorberg store longer under refrigeration than most other hardy varieties.

Approximately 200 apple and crabapple varieties, not generally available, are being propagated on Columbia crabapple rootstocks and maintained at Cheyenne for long-term evaluation.

2. Pears. In connection with the pear breeding program at Beltsville, 113 varieties and 80 numbered selections from other pear breeding programs have been established in a variety collection. A *Pyrus* species collection likewise has been established and 30 species or subspecies have been planted. A planting of twenty trees each of 7 varieties has been established to evaluate the relative fire blight resistance of these varieties under the usually severe blight conditions at Beltsville. The Stewart strain of Bartlett is reported to be more resistant to fire blight than Bartlett and is included in this planting.

3. Peach. At Fort Valley, 57 varieties were compared for chilling requirements by observing bud development in the greenhouse. In addition, all varieties and selections are being observed for their relative blooming time in the orchard.

At Fresno, prolonged dormancy was not a problem and there was little loss from bud drop. Collins was a little soft but smoother-shaped than Earlired. Earli Glo and Goldenred softened appreciably



at the tip, Garnet softened at the suture objectionably and Redgold softened at both suture and tip.

At Prosser Earlired continues to be the best variety in the very early season. Early Redhaven ripened almost as early as Earlired and had better undercolor but was smaller than Earlired.

4. Cherry. At Prosser, six commercially loose-packed boxes each of Chinook and Rainier were shipped to New York and Chicago markets under AMS direction in loaded refrigerator cars. Evaluation at the terminal markets by representative wholesale and retail buyers, AMS inspection and laboratory personnel, and market newsmen indicated Chinook was favorably accepted by both markets. Neither market was interested in a Napoleon-type cherry such as Rainier. Commercial propagation of Chinook and Rainier has continued to the limit of wood available. Pollination studies in 1961 and 1962 showed Van deficient in pollinizing at least 4 selections of which it was a parent and somewhat low in pollinizing Rainier. Bing was an adequate pollinizer for all selections studied except two of Bing parentage. Artificial hardiness readings were taken at 3 stages of dormancy for 190 varieties. These correlated well with readings made in 1961. Potentially hardy parents are being screened in this variety collection.

5. Plums. At Prosser, President and Edwards were each highly self-incompatible but each pollenized the other adequately and were pollenized adequately by several commercial varieties.

At Mandan, varieties, species and species hybrids are screened for winter hardiness, disease resistance, drought tolerance, late blooming and high quality under severe climatic conditions of the Great Plains.

6. Apricot. At Prosser, Earliril appeared superior to Blenril and Tilton for dual-purpose handling. It has better fruit-size and processing potential than Blenril and high quality, larger size, and better hardiness than Tilton.

7. Public Law 480 Research. In recent years numerous new varieties of deciduous fruit species have been introduced into Poland from the Soviet Union and China, particularly from areas of severe climate. Under United States sponsorship in P.L. 480 project E21-CR-6, phenological and pomological information was collected in Poland for the following: 53 apple, 37 pear, 19 peach, 12 plum, 42 apricot, and 5 sweet cherry varieties. Resistance of the plants to various diseases was also studied. Four apple species and six pear varieties were found to be immune to Venturia inaequalis and V. pyrina

respectively. Four clones of Chinese peaches were much more winter hardy than cultivated varieties in both field and laboratory tests.

#### D. Culture

1. Apple. Nutrition.  $Mg(NO_3)_2$  was much more effective in correcting Mg deficiency than was  $MgSO_4$  at Wenatchee, Washington, but the fruit failed to color properly because of the foliar absorption of nitrogen.

Physiology. The experiment to measure the effects of scoring on young Delicious apple trees at different levels of nitrogen and pruning was concluded at Wenatchee in 1962. The tree size was unaffected by pruning, but the addition of nitrogen increased growth while scoring of the trees reduced growth. Tree yields were substantially higher on the unpruned trees, but this was because of a greater amount of bloom rather than any difference in the fruit set. In most instances, scoring increased yields by increasing bloom and fruit set during the year following the scoring. This gain, however, was offset by lower yields when scoring was discontinued.

Although studies in 1962 confirmed the 1961 results that water core of Winesap apples at Wenatchee was correlated to increased total sugars in the fruit, evidence was found that water core cannot be attributed entirely to increased sugars of the fruit. Fruits with water core were found to show a slight increase in total sugars while the water core condition disappeared during the storage period.

Thinning. Comparisons between Sevin and NAA applications on the Delicious variety at Wenatchee indicate that Sevin is a more consistent thinning agent than is NAA. Concentrations as low as 1/4 lb. (50% wettable) of Sevin per 100 gallons were found to significantly thin. It is likely that Sevin can be used commercially at the rate of 1/4 to 1/3 lb. per 100 gallons for "easy to thin" varieties.

Working with  $C^{14}$  Sevin, it was found that Sevin was translocated to a slight extent in the foliage of the apple spur but does not enter the fruit to any extent when it is applied to the leaves. The result of fruit painting experiments suggest that Sevin has to be applied to the fruit and is either absorbed through the stem or calyx end. The site of action may be in the tissue at the point of seed attachment.



Growth Retardants. Preliminary tests at Wenatchee indicated that the growth retardant B-995 (N-dimethyl amino succinamic acid) was highly effective in reducing the vegetative growth of apple and cherry trees. The trees sprayed with 2000 ppm of the chemical had only 40 percent as much shoot growth as did the unsprayed trees.

Rootstocks. Six apple varieties propagated on seedlings of Malus baccata at Mandan, N. D. show a greater vigor at the end of two seasons than when seedlings of three crabapple varieties were used as the rootstock.

Tissues of Malling IX and seedling rootstocks were analyzed at Wenatchee to learn more about the chemical basis for the dwarfing caused by certain Malling rootstocks. The study is to be continued, but it has been found that less phloridzin was found in the Delicious trees growing on Malling than in seedling rootstocks.

Public Law 480 Research. Research, in Poland, is sponsored by the United States under provisions of P.L. 480 project E21-CR-7 entitled studies on growth promoting substances and inhibitors in apple trees during different stages of its development. One study was done to determine methods of improving branching and crotch angles on one-year-old nursery trees. Trees sprayed in the nursery with maleic hydrazide produced as many or more branches as manually decapitated ones. Auxin applications, such as IAA, NAA, and 2-4-D, to the bases of developing branches of young trees caused wide-angled crotches. Histological examination showed the wide-angled crotch to be due to auxin-stimulated cellular proliferation with associated mechanical pressure in the base of developing unligified branches. In concomitant studies of flower-bud induction in young, as well as bearing, apple trees, low concentrations of NAA stimulated, and high concentrations reduced, flower-bud formation. The influence of applied auxins, based on standard oat-coleoptile bioassay techniques, was interpreted as being an effect on endogenous inhibitors of oat-coleoptile elongation.

2. Peach. Rootstocks. Tests in the Fort Valley, Georgia area indicated that Nemaguard is probably the best nematode-resistant rootstock available for commercial use. Several other experimental rootstocks also showed promise in those tests. In one test comparing the two rootstocks Nemaguard and Okinawa, trees on Nemaguard are larger and sustained less injury from the conditions prevailing last winter and early spring. Further tests were made at Fresno of an acrita (nematode)-immune Nemaguard selection to determine its resistance to nematodes and general horticultural potential. Thirty-two Nemaguard x Okinawa seedlings now fruiting



were evaluated for nematode resistance, productivity, type of growth and general value. Seed from the better individuals were collected for further trials. Selections were made also in a progeny of selfed seedlings of a Nemaguard x (Yunnan x Red leaf) selection to develop a red-leafed rootstock resistant to nematodes.

At Beltsville, one selection from Nemaguard gave seedlings which developed no root knots from inoculation with either javonica or acrita nematodes. Five other Nemaguard selections were rated slightly better than Nemaguard in resistance to one or both nematode species.

Peach Replanting. In a cooperative experiment with the Georgia Agricultural Experiment Station, begun in 1958, tree-size differences among certain soil treatments continue to be promising. Trees growing in soil treated with Fumazone, Dowfume 85, and methyl bromide were outstandingly more vigorous than checks.

Many thousands of trees died during February and March, 1962 in the Southeast. It is estimated that as many as 300 thousand trees were lost in the area known as Middle Georgia (commonly referred to as "south of Macon"). Additional thousands of trees in that area showed variable damage but later recovered. Injury symptoms on trees were similar to those noted in previous years in which loss of trees was much smaller in number. Considerable time was spent in attempts to determine the possible cause of the damage. Although all the factors involved were by no means determined, there is strong evidence that relatively high temperatures in late January and early February followed by a drop in temperature to 22°F. in the morning of February 7 were an important factor.

Chemicals to delay blossoming. No consistent delay in blossoming has been observed at Beltsville or Prosser from soil drenches or sprays of CCC (2-chloroethyl-trimethylammonium chloride) or Phosfon (2-4-dichlorobenzyl tributyl phosphonium chloride). At Fort Valley, this work was inactive during 1962.

Chemicals for thinning. At Beltsville, four N-substituted maleimides and N-dimethyl amino succinamic acid received preliminary trials for post-blossom peach thinning effects on Redhaven. Only N-(M-chlorophenyl) maleimide was active in this respect, but some foliar injury and defoliation at the higher concentrations tested precludes further evaluation.

Public Law 480 Research. In recent years a correlation between dormancy and flavone fractions in apple and peach have been demonstrated. Flavones are yellow pigments occurring in plants and one, called Naringenin, has been specifically identified under United States sponsorship in P.L. 480 project A10-CR-8 the role of Naringenin was studied in Israel in a project entitled the physiology of rest (dormancy) and its application to fruit growing. Appropriate analytical and bioassay techniques were developed to extract and analyse the Naringenin content and effect in peach leaf- and flower-buds. Quiescence of buds was associated with high levels, and bud-break of both leaf and flower buds associated with low levels, of the flavanone Naringenin. In other tests, naturally occurring, as well as synthetic, Naringenin was shown to have growth regulating properties. The researchers suggest that Naringenin is an obligatory factor governing leaf- and flower-bud break. In other studies to relate Naringenin content of buds to their chilling requirements, the content of this flavanone tended to be reduced by an accumulation of hours of chilling, but other endogenous and environmental factors were also operative.

3. Cherry. Rootstocks. At Prosser, a cherry rootstock planting produced its first crop. The Van variety outproduced Bing and Lambert on all rootstocks. Van also made greater trunk circumference gains, and matured earlier in the fall, than Bing. Trees on clean mahaleb stocks out-produced those on mazzard or Turkish mahaleb. Trees on mazzard were slower in maturing their wood. Sweet cherries with Montmorency trunks and crotches produced well although the sweet cherry portion was a year younger than other treatments. Turkish mahaleb interstocks also gave precocious bearing despite roots essentially a year younger than other treatments. P. fruticosa was an unsatisfactory rootstock because of excessive suckering, poor bud-take and poor anchorage.

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SMALL FRUIT CULTURE, BREEDING AND GENETICS,  
DISEASES AND VARIETY EVALUATION  
Crops Research Division, ARS

Problem. New improved varieties of small fruits and grapes are needed that have broad regional adaptation suitable for modern commercial use. Needs include large (for ease of picking), firm-fruited (for best handling), disease-resistant varieties for freezing and for long distance or local marketing, with a sequence of ripening throughout the season. Determination of causal agents of new diseases is needed, and methods should be developed for effective and economical control of important fungus, nematode, and virus diseases of berries and grapes, with emphasis on identification and control of viruses in strawberries, raspberries, and grapes. The testing and critical evaluation of varieties for yield and important horticultural characters, such as fruit size, firmness, color, and quality, are needed in relation to regional adaptation. Also needed are improved cultural practices in propagation and plantation management that will result in high production of good quality fruit and reduced production costs. This entails new information on environmental factors limiting production and on inter-relationships of temperatures, soil moisture, diseases, and nutrition on plant growth, hardiness, and productivity.

USDA PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, and horticulturists engaged in both basic studies and the application of known scientific principles to the solution of growers problems. European bunch-grape breeding, disease, varietal evaluation, and cultural research at Fresno, California, is cooperative with the Fresno State College. Strawberry breeding research at Salisbury, Maryland; Willard, North Carolina; and Corvallis, Oregon, is cooperative with the respective State Experiment Stations; and in addition, strawberry breeding and cultural work at Carbondale, Illinois, is cooperative with Southern Illinois University. Raspberry and blackberry breeding research at Corvallis, Oregon, and Carbondale, Illinois is cooperative with the Oregon Agricultural Experiment Station and Southern Illinois University respectively. Blackberry cultural research at Corvallis, Oregon, is cooperative with the Oregon State Agricultural Experiment Station. Blueberry breeding research at Gainesville, Florida; Tifton, Georgia; Jonesboro, Maine; and Ivanhoe, North Carolina; and breeding and disease research at Hammonton, New Jersey, is cooperative with the respective State Experiment Stations. Cranberry breeding research

at East Wareham, Massachusetts; and disease research at New Brunswick, New Jersey, is cooperative with the respective State Experiment Stations. Breeding research (strawberries and raspberries) is done at the USDA Horticultural Field Station, Cheyenne, Wyoming. Breeding, disease, varietal evaluation, and cultural research with Eastern bunch grape, and breeding research with muscadine grape, is carried on at the USDA Horticultural Field Station, Meridian, Mississippi. At Beltsville, Maryland, breeding, variety evaluation, and disease research is done with Eastern bunch grape, strawberry, blackberry, blueberry; and cultural studies are done with the Eastern bunch grape, blueberries, blackberries, and strawberries.

The Federal scientific effort devoted to research in this area totals 12.5 professional man-years. Of this number 5.7 is devoted to breeding; 4.5 to diseases; 1.1 to variety evaluation; 1.0 to culture; and 0.2 to program leadership.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Breeding

1. American Bunch Grape. Breeding of American type bunch grapes was continued with no change in objectives at Meridian, Miss. and Beltsville, Md. At Beltsville, 31 crosses yielded 5,211 seeds with the major objectives being black rot resistance and crisp fleshed vinifera type table grapes, both seeded and seedless. Of these, 1959 seeds in 13 crosses were planted and are now being screened for black rot resistance. More than 775 seedlings in 5 progenies were screened for black rot resistance in 1962 of which 246 were classed as resistant and planted in the nursery; and 1136 seedlings were screened for other horticultural objectives and planted in the nursery in 1962. Almost 600 black-rot-resistant seedlings that were screened in 1961 were planted in a fruiting vineyard. Fifteen seedless selections were propagated for more extensive testing. The US 4801-38 selection continued to appear promising as a late ripening vinifera type grape.

At Meridian 14 selections have been selected and over a period of years continue to be as vigorous as Champanel, the Pierce's Disease tolerant variety. Five of these are under extensive tests at other locations. About 800 1- and 2-year-old seedlings are ready to plant in the fruiting vineyard. Twenty-two of the bunch-grape x muscadine hybrids selections from Raleigh, N. C. have been planted at Meridian and 37 others have been obtained as unrooted cuttings. About 140 unselected  $F_2$  hybrid seedlings from the North Carolina work are now established in the vineyard.



2. Muscadine grape. Work was continued at Meridian, Miss. where the emphasis is on origination of perfect flowered, high quality varieties and species hybrids with bunch grapes. Eight perfect-flowered, high-quality muscadine grape selections are under extensive tests throughout the southeastern states with sufficient fruit to test processing quality for jellies and jams. Thirty-six other muscadine selections are under test. The 2200 seedlings placed with a private grower for fruiting tests made excellent growth. Crosses made in the spring of 1962 yielded about 400 seeds. Seedling growth the first year from the original 21 colchiploids (tetraploids) made  $1/3$  to  $1/2$  as much growth as tetraploid seedlings that originated from later colchiploids. Many of the more recent tetraploid seedlings are growing vigorously in the vineyard and appear promising because of large fruit size.

3. European (Vinifera) Grape. In 1962 at Fresno 126,914 vinifera grape emasculations and pollinations resulted in 5805 hybrid seeds which amounts to almost 1 seed for every 20 pollinations and 4131 seedlings from the 1961 hybrid seed were planted in the field.

During 1962, 75 vines bearing seeded grapes, 31 vines producing grapes with only a trace of seeds, and 9 vines producing completely seedless grapes were selected for further evaluation. Nine selections are now in commercial trials: 5 are white seedless grapes (11-62, 23-188, 35-33, 47-23, and 58-93); 2 are black seeded grapes (10-79 and 27-31); 1 is red and seeded (26-55); and 1 is white and seeded (12-19).

The seedlings having commercial potential are: 26-55, Queen x Ribier, a very firm mid-season grape; 35-33, a very early ripening seedless grape having Thompson, Perlette, and Muscat of Alexandria in its ancestry; 58-93, a mid to mid-late seedless having Calmeria, Thompson Seedless and Muscat of Alexandria in its ancestry; and possibly 27-31, Flame Tokay x Ribier, a mid-late black.

Of 5346 seedling vines grown for five years (1958-1962) 940 or 17.5% failed to fruit. The percentage failing to fruit in different crosses ranged from 0% for 19 crosses up to 100% for 2 crosses. The most striking 19 representatives of the unproductive vines ranging in vigor from extreme dwarf up to very vigorous are being given further study and screened for known virus diseases.

4. Strawberry. Work at Beltsville, Md. and cooperatively with experiment stations in Md., N. C., Oreg., and Southern Illinois Univ., emphasizes, as major objectives, resistance to red stele root rot, verticillium wilt, foliage diseases, and virus tolerance in combination with good horticultural characters. At Willard, N. C., 9 strawberry selections have been distributed to southeastern United States for advanced tests. About 300 selections were evaluated in

the spring of 1962 and more than half of which were discarded; 47 new selections were made from among 6,200 seedlings that had been planted the previous year; and 14 progenies were analyzed for genetic characteristics. Approximately 10,000 seedlings from crosses made in 1961 and 1962 are now ready to be planted in the field. The 6,900 new seedlings set in the field in 1962 will be evaluated for fruiting this spring.

In Maryland 4 selections (Md-US 2593, 2601, 2700 and 2830) appear promising and are nearing a final evaluation. Four newer selections (Md-US 2905, 2910, 3068 and 3082), from more than 250 on test, also appear very promising and all are resistant to red stele; and 116 new selections were made from about 6400 seedlings on test. Approximately 5,200 resistant seedlings from last year's screening test will fruit in the spring of 1963. About 26,700 seedlings were planted in red stele infested soil and additional crosses have been made to yield approximately 60,000 seeds. Red stele screening tests with race A-5 have revealed that F. chiloensis is one of the best sources of resistance. Of 128 clones of wild Fragaria species collected at random, 13 were resistant to race A-5.  $F_1$  selections of chiloensis with cultivated varieties were as resistant as the chiloensis parent. Of 17 Potentilla species screened for resistance to race A-5, 5 were susceptible, and 12 were immune. An isolate of race A-5 was found capable of infecting Yaquina F. chiloensis which previously has been immune.

At Carbondale, 91 selections were made from 6,000 seedlings planted the previous year and these were transplanted into row tests for further evaluation. In the advanced variety trial that fruited for the third year, varieties that were most productive the previous year continued to be the most productive. Of 28 SI-US selections screened at Beltsville in 1962-63 for resistance to red stele, 5 were immune to race A-1 and others were highly resistant. Evaluation of 189 SI-US selections made since the start of the work was continued. About 6,000 seedlings are now in the greenhouse ready to be set in the field. The Md-US 2593 and 2601 selections continue to appear very promising and are being tested on a large plot basis.

At Corvallis, from approximately 5,000 new seedlings that fruited in 1962, 95 selections were made. Eleven of these are highly resistant to red stele. Of 13 selections rated as very satisfactory in frozen pack tests, 5 were selections that have been rated satisfactory previously, and one of these, Oreg. US 2575, is being rapidly propagated for extensive testing. From a large collection of F. chiloensis from the Oregon Coast 33 clones were immune to red stele and these are being used as parents in making crosses with cultivated varieties.



5. Raspberry. Raspberry breeding was continued at Corvallis, Oreg. and Carbondale, Illinois. Objectives at Corvallis emphasize large, firm-fruited varieties for frozen pack and canning that are tolerant of heavy, wet soil conditions. Objectives at Carbondale include origination of disease resistant types and winter hardiness. At Carbondale 30 selections were made from a seedling block of 1,200 plants, part of which are summer fruiting selections. Some of these have been severely damaged by winter conditions this year and will be discarded, but the remainder have been propagated and will be planted in a replicated block for further evaluation. At Corvallis, 16 new selections were made that are being propagated for further testing. Almost 750 new seedlings were put in the field from new crosses that were made in 1961.

6. Blackberry. Work was continued at Corvallis, Oregon and Carbondale, Ill., where the principal objective is the origination of thornless upright and trailing blackberries. Selection and evaluation is being continued at Beltsville where 3 selections (US 1482, 1503, and 1523) looked particularly promising but further testing is necessary to determine their winter hardiness. At Corvallis the 8 most satisfactory selections for canning and freezing are 1063, 1105, 1120, 1122, 1123, 1127, 1191 and 1268. Selection 1063 appears to be the hardiest of the group and is being tested extensively in northern Washington. More than 750 new seedlings were set in the field last year and more than 1,000 will be set this year. Thirteen new selections were made of which 10 were thornless; and selection 1282, a productive, thornless, good quality selection was found to be winter hardy and is being propagated for extensive tests. At Carbondale a low temperature of  $-18^{\circ}\text{F}$  provided a severe test for winter hardiness on the thornless blackberry seedlings and selections; many were killed to the ground but several appear hardy. Data which included vigor, productivity, hardiness and fruit size were taken in 1962 on 4,000 seedlings planted in 1961. Many of the seedlings appeared very vigorous under the soil and environmental conditions at Carbondale. About 3,500 seedlings planted in the spring of 1962 are being moved to the field for fruiting tests.

7. Blueberry. Blueberry breeding objectives are: for the northern states, development of consistently productive, cold hardy types with large fruit size, high quality and small, dry scars; in North Carolina for cane canker resistance in combination with large fruit size and good color; in Florida for early ripening varieties with low chilling requirements; and in Georgia for origination of large fruited, high quality, early and late ripening rabbiteye types. Work is cooperative with Florida, Georgia, North Carolina, New Jersey, and Maine Agricultural Experiment Stations and with a private grower in each of Connecticut, Michigan, New Jersey, Massachusetts, Pennsylvania and North Carolina. In Florida approximately 14,000 young seedlings from crosses made for low chilling requirements were set in the



nursery. Selections were made in 1962 based on degree of bud break and desirable fruit characters. Seedlings from progenies having  $1/2$  or  $1/4$  V. darrowi parentage required low chilling whereas the bud break and vigor of progenies having only  $1/8$  V. darrowi was poor. Woodard and Homebell varieties exhibited a shorter chilling requirement than did Tifblue. In Georgia several selections ripening earlier and later than Woodard and Tifblue appear promising; these include T-13, T-20, T-65, T-70 and T-94. More than 1,000 new seedlings were set in the field for fruiting tests. In North Carolina the most promising cane-canker resistant selections are 665, 678, 683, 690, 697 and 705. These are being evaluated in a planting where Wolcott is showing cane canker damage. Since these selections differ in time of ripening, from very early to later than the Murphy variety, all are potential varieties depending on their cane canker resistance. In New Jersey a frost on May 9, after which Bluecrop and Bluegray were the only varieties with a full crop, provided a screening test for blossom hardiness, 12 selections from previous years were rated as outstanding in hardiness, cropping ability, and other fruit characters and are being extensively tested. About 8,000 new seedlings were planted for fruiting tests. In Michigan, 8 new early ripening selections were made in a seedling field and 12 older selections were rated outstanding. About 1,125 new seedlings were planted. In Maine out of about 5,475 seedlings on test, 148 were selected for further evaluation in 1963. Most seedlings with Ashworth parentage had little injury while a nearby progeny of Herbert x Bluecrop was almost fruitless and showed severe wood and cane injury. Two native wild selections, Me. 5005 and Me. 5009, and a hybrid selection, Me.-US 1-72, exhibited unusual winter hardiness and these are being used as parents in further crosses. About 4,500 new seedlings were planted in Maine. At Beltsville over 100,000 seeds were harvested from 44 crosses. A total of 11,855 seedlings were grown in the greenhouse and distributed to cooperating growers for fruiting tests. Origination of a new type of blueberry was apparently accomplished by doubling the chromosome number by colchicine treatments, of a 5X hybrid selection of rabbiteye x highbush blueberries: flowers on the affected branches have thicker pedicels, are larger, and have larger, more plentiful pollen than the 5X controls. Vegetative buds were successfully treated by a water solution of colchicine, but a glycerine solution of colchicine killed all treated tissue. The 5X hybrid is self-unfruitful, whereas the colchipploid appears to be self-fruitful. This is the first time that the chromosome numbers of blueberries have been experimentally doubled. In Massachusetts the planting has not recovered from severe winter damage suffered 2 years ago and no new selections were made nor any new seedlings planted.

8. Cranberry. No new cranberry breeding was done but final evaluation of 14 selections continues. These are under test in cooperation with the Massachusetts Agricultural Experiment Station at East Wareham.

9. Small Fruits for the Great Plains. Breeding of winter hardy raspberries and strawberries are the objectives in work at Cheyenne, Wyoming. Selections were from among 7,000 strawberry seedlings set in the field in 1961 and an additional 4,500 seedlings were planted in the spring of 1962; 184 selections are on test from breeding work in 1956-1958 and 23 of these were set in matted row tests.

## B. Diseases

1. Grape. Grape viruses. Rapid detection of viruses by new methods, the effects of virus complexes on vines, and the establishment of virus-free clones continue to be the major problems. Much of the research is being done in California with a limited amount at Beltsville. At Beltsville no symptoms appeared under greenhouse conditions when 60 collections of 28 important bunch grape varieties were grafted onto the indicator variety Baco 22A for detection of leaf roll virus. In California the grape viruses now recognized are Pierce's disease, leafroll, fanleaf, yellow mosaic, vein banding, yellow vein, astroid mosaic and corky bark. No transmissible enation has been discovered in California vineyard surveys such as that which apparently occurs in Germany and Italy, nor the "Flavescence dore" which occurs in France and Germany. The LM-33 indicator when budded with some vinifera varieties yielded symptoms of corky bark (usually death of LM-33) which is now recognized as the same as rough bark. Corky bark inoculations gave symptoms on Bouquet and Gasconade, but not on 20 other bunch grape varieties. Vinifera vines infected with corky bark are best diagnosed in the fall, as they retain their leaves long after the leaves on healthy vines are killed by frost. A block of Mondeuse had 8% corky bark and in a block of Cabernet Franc the incidence was 4%.

Recent evidence indicates all of the soil-borne virus diseases (fanleaf, yellow mosaic, vein banding) of grapes are probably caused by strains of a single virus transmitted by the nematode, Xiphinema index. Serologically the diseases are similar and all diseases give similar shock reaction when transmitted to St. George indicator vines. Three distinct and fairly stable disease syndromes can be differentiated by use of appropriate indicator plants. None of 176 seedling vines with fanleaf-like symptoms obtained from parent vines with fanleaf had fanleaf when indexed. Fanleaf virus may have caused genetic changes in progeny vines that are nontransmissible. Root fragments from a site where fanleaf diseased vines were removed were still viable after 3 years. Callus tissue produced by these fragments transmitted fanleaf when tested on chenopodium, an herbaceous indicator plant, and therefore such fragments serve as reservoirs for virus in the soil.



Numerous strains of leafroll virus appear to exist and there is no evidence for natural spread of this virus. Index tests were established to determine whether vines differing in symptom severity will transmit the same relative degree of severity to indicator vines. Baco 22A was an excellent indicator for leafroll when your vines were budded in the spring and set in the field; but, when similar Baco 22A vines were budded and held in the greenhouse, symptom development was obscure. Vines of varieties with mild symptoms of leafroll gave clear-cut symptoms when indexed on Baco 22A. A new diagnostic symptom of leafroll in Baco 22A was found in which the leaf blades and petioles on infected vines form an acute angle of about  $43^\circ$  whereas leaf blades on healthy vines have nearly right angles with the petioles. Moisture in leaves on mid-portions of canes from leafroll diseased vines was less than in healthy vines. Radioaudiographs of leafroll diseased tissues indicated that movement of radioactive potassium into leafroll-infected leaves was less than into the leaves of healthy vines, but that the radioactive potassium moved into shoot tips and buds of both leaf roll and healthy vines about the same time. A new clone of Mission, which appears to be free of all strains of leafroll, has been tested as an indicator for leafroll. In a study of leafroll in relation to powdery mildew, frost tolerance of vines, and moisture content of the leaves in 25 varieties, high correlation coefficients were obtained. The correlation values indicate that powdery mildew resistance, frost tolerance and water content of the leaves are inter-related and that leafroll infection may change the relationships by reduction of moisture in the foliage of infected vines.

In a 10-year old NP&K fertilizer experiment, in which vines were placed in high, medium and low yield groups, most of the vines with low yields were found to have leafroll whereas most of the vines with high yields did not. In another experiment where chelated Fe and Zn were applied to vines uniformly infected with fanleaf and leafroll no masking of symptoms nor change in sugar content of fruit occurred. Differences in yields were not clear-cut. When K was applied to paired healthy and leafroll infected Zenfandel vines some increased yields from K fertilization occurred on leafroll-infected vines.

Virus-free vines of 3 root-stock varieties, 10 table and raisin varieties, and 23 wine grape varieties have been selected for planting in the spring of 1963. By 1964 additional virus-free varieties available will be: 2 rootstocks, 2 table and raisin varieties, and 9 wine varieties.

A rooted cane tip taken after a 56 day heat treatment from leafroll infected Cardinal was free from leafroll whereas another cane tip from the same source rooted after only 29 days of heat was still infected. Tips of vines from 33 different grape varieties, in which no healthy clones were found, have now been rooted following heat treatment periods in excess of 56 days. They are now being indexed, and



their appearance in the nursery indicates these vines are probably free from all known viruses. Heat treatment and tip propagation is being incorporated as a standard practice for the introduction of new grape varieties into California.

2. Strawberry. Red stele. From a collection of red stele infected strawberry plants from 52 locations in Oregon and Washington, 8 distinct isolates of the fungus have been obtained thus far and the work is continuing to isolate additional cultures. Identification of the initial isolates of the fungus from Oregon and Washington indicates the existence of races A-1, A-2, A-3, A-4, and A-5. Storage of Phytophthora fragariae on agar slant cultures under sterile mineral oil at 5°C resulted in 76 percent viability of transfers after 26 months of storage. Usually it is necessary to transfer the cultures at least once a year when stored at 5°C without oil immersion. Attempts to inoculate dormant plants by soaking the roots in water spore suspensions for 2 weeks at 40°F has not been successful. The Yaquina variety inoculated with race A-5, and normally immune to it, was found to have oospores in the roots which suggests the origin of a new virulent race.

Virus diseases. Work continued at Beltsville, Md. and Corvallis, Oreg. to determine the effect of virus complexes on different varieties and selections, the expression of symptoms, and new methods of freeing plants of virus through chemotherapy and excision of growing points. In Oregon the varieties Columbia, F. virginiana Sheldon, and Puget Beauty were the most virus tolerant of 218 selections and varieties tested for tolerance to a severe yellows virus complex. Several F. chiloensis clones collected along the Oregon coast also proved to be highly tolerant of a virus complex but none were immune. In an attempt to chemically inactivate a yellows virus complex, 8 out of 19 plants treated with 6 methyl purine appear to be virus free; whereas 16 of 23 plants treated with 6 methyl purine and then put in a hot air chamber at 100°F for several days were virus free. Two of 10 plants obtained by excision of apical meristems were found to be free of vein banding virus and 4 of 7 plants that had been infected with crinkle virus were found to be free of all viruses. Two virus-free Northwest variety, and 1 virus-free Rockhill plants were obtained by this technique from plants originally infected with the yellows virus complex. These have been propagated for distribution to commercial nurseries. Mild crinkle and yellow edge viruses were not transmitted in tests with Xiphinema, Longidorus and Trichodoros nematodes.

In a search for clean, virus-free plants of 11 varieties and 190 selections, all plants of Rockhill, Northwest, Paris Spectacular, and 20 percent of the selections were completely virus infected. A survey of certified foundation nursery stocks indicated approximately 3 percent of the plants infected with viruses. Fifty-five varieties

and selections were propagated as virus-free stocks in the propagation center for distribution to plant growers or for research use.

At Beltsville 6 varieties freed of Latent A virus by heat treatment-excised bud technique were planted for comparison with standard stocks and a visible increase in vigor of Latent A free clones was observed in Catskill, Fairfax, and Redstar. Some increase in vigor occurred in Latent A freed clones of Midland and Redglow. Clones of Pocahontas with mild Latent A, and without Latent A, were more vigorous than plants with Latent A. Stocks of 7 varieties free of Latent A have been screenhouse propagated for distribution to State certification agencies. Virus-free plants have been successfully developed from runner tips and apical meristems using standard aseptic tissue culture techniques.

Fruit rot. At Beltsville a laboratory dip inoculation with conidia of Botrytis cineria, involving 70 varieties and selections of strawberries, gave marked differences in the rate at which fruits rotted. Apparently resistant varieties were Cascade, Redgauntlet, Md-US 2830, NC 2355, and NC 2411. Highly susceptible ones were Earlidawn, Headliner, Howard 17, Md-US 2289, and NC 2486. Latent infection of field-grown fruit was also high with nearly half the berries being rotted in 7 days after harvest. When fruits were inoculated at different stages of maturity, the rate of infection increased as the ripeness of the fruit at time of inoculation increased.

3. Raspberry and blackberry diseases. Development of virus-free Rubus stocks and their possible establishment in commercial nurseries in eastern United States are the main objectives of the present work. Investigations of the identity and mode of spread of the major Rubus viruses in eastern United States are also being conducted.

A 2-year old yield test was completed in the fall of 1962 at Beltsville, Md. in which virus-free stocks of Newburgh and Durham varieties outyielded virus-infected stocks. Fruit yields of virus-free Newburgh were 117 percent greater than mosaic infected stocks and virus-free Durham was 32 percent greater than virus infected plants. Berries from virus-free Newburgh plants appeared to be less crumbly than those from mosaic infected ones. Fruit yield was correlated with vigor of the plants as measured by number of canes per plot. Invasion of virus into virus-free test plantings in Md., N. J., and N. Y., where stocks were isolated from other Rubus by 1200 feet or more, occurred in only 1 plant in 1 location. Indexing of stocks of several red and black raspberries by leaf grafting to Rubus henryi, an indicator variety, revealed the presence of viruses lethal to henryi in 6 of the varieties. These had appeared symptomless and had been considered virus-free on the basis of repeated indexing to black raspberry seedlings. The identity of the viruses involved is



not known, but their prevalence in black raspberry stocks was unexpected as black raspberries normally do not harbor viruses in symptomless condition.

The ability of vector aphids (Amphorophora rubi) to spread heat-labile viruses of the raspberry mosaic group in relation to temperatures was tested. Adult apterous *A. rubi* remained viruliferous for more than 8 hours at 10°C, but lost their virus activity in 4-6 hours at 26-32°C, and the aphids failed to live after exposure at 38°C for 1 hour.

Plum Farmer was found to possess true immunity to the beta curl virus by a series of grafts in which Plum Farmer was leaf grafted with the virus and then subsequently grafted to the susceptible Cuthbert.

In a study of mild streak virus Fragaria vesca clone V9, previously reported as an indicator for mild streak, was found to remain symptomless when leaf grafted with the mild streak virus. Mild streak was not transmitted mechanically to cucumber from black raspberry. Symptom expression and development on black raspberry was increased by growing plants at 30°C with 16 hour daylengths. Virus-free stocks (as indicated by indexing to *Rubus henryi*) of the following varieties have been established and propagated at Beltsville: Durham, Latham, Newburgh, Sunrise, Taylor, Canby, Cuthbert, Fairview, Milton, Puyallup, Sumner, Washington, and Willamette of the red raspberries; and Dundee, Plum Farmer, Bristol, Cumberland, and Morrison of the black raspberries. Some of these are being distributed in 1963 to State agencies. Small scale pilot tests for commercial propagation of virus-free raspberries have been established in N. J., W. Va., N. Y., and Mich., in cooperation with State agencies.

4. Blueberry. Major work in blueberry diseases continues to be a study of viruses and their control. New research was initiated on blueberry anthracnose and powdery mildew. A survey of experimental and commercial blueberry fields in New Jersey indicated a high incidence of red-ringspot virus disease. The varieties, Burlington, Cabot, Bluejay, and Stanley had the greatest incidence of the disease whereas little or no infection was found in Jersey, Weymouth, Concord, and Berkeley. Many of the young hybrid seedlings were found to be infected. Work is in progress with red ringspot to determine the vectors and whether heat treatment will inactivate the virus. Circumstantial evidence indicates that necrotic ringspot of blueberry is transmitted by nematodes. Proof of the blueberry necrotic ringspot being a form of tobacco ringspot was obtained. The virus has been recovered from roots and fruit of watermelon grown in the field near infected blueberry plants, from the roots of watermelon grown in the greenhouse in pots with infected blueberry plants, and from watermelon grown in soil taken from fields known to have infected blueberries. A survey for shoestring virus was initiated which indicated



the disease is not spreading rapidly. Blueberry anthracnose fruit rot caused by Glomerella cingulata has been effectively controlled with Maneb, M-45 and NIA-9102. Careful pruning to eliminate sources of inoculum from dead twigs did not decrease rot incidence. Two fields were observed where anthracnose fruit rot was causing extensive damage. Effect of powdery mildew on yield was inconclusive because of low mildew incidence, but work will be continued.

5. Cranberry. The screening program for new chemicals to control cranberry fruit rots continued in New Jersey and M-45 and NIA-9102 compared favorably with Maneb and Zineb. A survey of 32 bogs on 11 different properties indicated a range of rot incidence from 2 percent to 100 percent. Cultures from rotted fruit revealed that Guignardia vaccinii, Physalospora vaccinii, Godronia cassandrae, and Sporonema oxycocci were all present. A high percentage of the berries were infected with S. oxycocci. Berries with mottled, virus-like symptoms were observed from 3 bogs and plants were tagged for further investigation on the possible virus nature of the trouble.

### C. Varietal Evaluation

1. Grape varieties. At Beltsville, 9 additional eastern varieties were planted in the vineyard. Cuttings of 23 selections and 11 species were obtained from several sources and propagated in a nursery.

Rootstocks. At Fresno during spring 1963, 343 bench grafted rootstocks, and 110 rootings of 11 rootstock varieties were distributed to 3 California Farm Advisors for tests in problem areas. The demand is active for some rootstocks that will produce vigorous healthy vines in old vineyard areas where soil pests are prevalent.

Intensive study continues on about 30 seedling rootstocks that have survived from among the 1155 seedlings produced from crosses made in 1957. The warm (80°F) humid heat chamber gives an accurate reading on the rootability of these rootstocks and is vital for the successful bench grafting method.

Twenty-eight of 36 rootstock seedlings, resulting from 4 crosses made in 1961, were free of root-knot nematode galls when field planted in inoculated soil during 1962. All are being given a rootability test in the warm, humid propagating chamber.

2. Raspberry. At Cheyenne, the evaluation of raspberries that fruit on the current season's canes is being continued.

### D. Culture

1. Grape. Three years of bench-grafting trials were completed during 1962 and a high degree of grafting success is feasible with the proper

rootstocks. During 1962-63 winter season, the Thompson seedless has been bench-grafted on 27 rootstocks varieties and successfully grown with the graft union exposed by means of waxing the scion and graft union after callusing, but before planting in the greenhouse, to eliminate the scion-root problem. Of 800 grafts attempted, 90 percent were successful and success ranged from 100 percent for 9, down to 58 percent for 1, varieties. The grafting tests are being repeated to obtain additional plants for field tests.

At Meridian, in a 13 year test of the Delaware variety on 9 rootstocks, fruit yields of 8 pounds or more, and cane prunings of 2 pounds or more, were obtained from that variety grafted on B-4 5, a triploid muscadine bunch grape hybrid), Herbamont, V. riparia x V. berlandieri 161-49, and Vermorel rootstocks. The test will be terminated at the end of this season.

2. Strawberry. Preliminary studies at Beltsville with the variety Florida Ninety indicated that a temperature of 60-70°F was more satisfactory for fruit development than a temperature higher than 70°. Fruit was nearly 50 percent larger at 60-70° than at 70-80° and blossoms failed to set at 90°. Weekly sprays of gibberellic acid begun September 1 and continued to November 1 at 15 and 30 ppm failed to prevent blossom formation, and elongation of the crowns was affected.

Dormant plants, when placed in the greenhouse on March 1, and sprayed with 25 and 50 ppm of gibberellic acid Dec. 15, Jan. 1, Jan. 15 and Feb. 1 blossomed from 7-10 days earlier than the controls. At Carbondale a replicated block of 3 strawberry varieties was established for a study of the effect of post harvest defoliation and the foliage of the test plants was mowed off after fruiting in late June of 1962.

3. Blackberry. In Oregon severe injury during the winter of 1961-1962 occurred on blackberry selections and varieties that were tied to the trellis wires in August. Blossom sterility occurred as a result of damage to flower buds even though the canes did not show injury. In the eighth year of a long-time fertilizer study in Oregon with Marion blackberry yields were low and inconsistent as a result of winter injury to canes. The experiment has been terminated.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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TREE NUT CULTURE, BREEDING AND  
GENETICS, DISEASES AND VARIETY EVALUATION  
Crops Research Division, ARS

Problem. Tree nut production in the United States is much below the national consumption and needs to be materially increased. Production is limited by the need for better varieties that are more productive, disease resistant, of better quality, and less subject to spring frosts. More information is needed on nutritional requirements and the factors that induce biennial bearing. Diseases are often limiting factors and may even cause complete crop failure. Almonds are particularly subject to late frosts; later blooming varieties are feasible. Nut trees are known to have higher potassium requirements than the trees can absorb in heavy crop years. Methods of inducing increased absorption are needed. Tree nut crops have relatively low per acre production. New information is needed on tree spacing, dwarfing, rootstocks, and chemical fruit setters as well as more productive varieties to increase production per acre.

USDA PROGRAM

The Department has a continuing long-term program involving breeders, plant pathologists, soil scientists, and horticulturists engaged in both basic studies and the application of known principles to the solution of growers' problems. Almond breeding research at Fresno, California, is cooperative with the California Experiment Station. Filbert breeding and cultural research at Corvallis, Oregon, is cooperative with the Oregon Experiment Station. Pecan breeding, variety evaluation, disease control and cultural studies at Meridian are cooperative with the Mississippi Experiment Station. Disease control and orchard management at Albany, Georgia; disease control, orchard management and nutrition at Shreveport, Louisiana; variety evaluation, orchard management and breeding at Brownwood are at federally operated stations. Research on walnut diseases and culture at Corvallis, Oregon, is cooperative with the Oregon Experiment Station. Breeding research and variety evaluation (chestnuts, filberts and hicans) is carried on at Beltsville, Maryland.

The Federal scientific effort devoted to research in this area totals 11.5 professional man-years. Of this number 1.7 is devoted to breeding; 1.5 to diseases; 1.3 to variety evaluation; 6.5 to culture and 0.5 to program leadership.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Almond. Hybridization of almond and the nematode-resistant Nemaguard rootstock variety to provide vigorous and adapted rootstocks for almond were complicated by poor pollination between the species. However, seedlings of a selection having Prunus mira and P. amygdolus in its parentage have shown nematode resistance equal to Nemaguard. Such seedlings are valuable sources of potential rootstocks for almond.
  2. Filbert. A high proportion of empty nuts at maturity continues to be the number one problem in filbert breeding at Beltsville. Most seedlings and varieties produced upwards to thirty percent blank nuts in 1962 and one male-sterile tree produced ninety percent such nuts. The use of chemical growth regulators failed to alleviate the situation. Abnormal pollen grains of some seedlings suggest gametic aberrations and accompanying sterility as a cause of the blank-nut phenomenon.
  3. Chinese Chestnut. Irradiated trees of the Nanking chestnut variety that had produced abnormally branched catkins the previous two years formed only normal catkins in 1962, indicating a slow recovery from the effects of radiation. These trees are planted eight feet apart and produced nuts the first year they were planted. In 1962, in the third season of growth, they produced nuts at the highly productive rate of three thousand pounds per acre.
- Two new Chinese chestnut varieties, Orrin and Crane, were introduced at Beltsville in 1963. Both of these varieties are superior to all others in keeping quality of the nuts and in earliness to come into bearing. Orrin has a relatively short growing season because of late flowering and early maturity which suggests a potential adaptation in more northern areas.
4. Walnut. Two progenies of Carpathian walnut fruited for the first time and one seedling having well-filled nuts, a very thin shell, and excellent cracking and eating quality was noted.

The great variability among second generation seedlings from Juglans regia x J. nigra hybrids emphasizes their potential value as sources of new and superior walnut varieties.



5. Pecan. Two new pecan varieties were named and introduced at Brownwood, Texas in 1962.

Apache was introduced because it combines good production, and good tree vigor with desirable nut size, shape and cracking quality and high percentage kernels which do not deteriorate rapidly in storage. It is recommended for the sandy uplands of Texas and the western pecan areas where it has performed well under tests. It has not been amply tested for scab resistance and since its Burkett parent is notably scab susceptible, it should not be widely planted in the humid areas of the Southeast until its scab resistance and production performance is better known.

Sioux was introduced because of its exceedingly good kernel quality and its ease of cracking by commercial machinery. It also combines good tree vigor and good production. It has not been tested for resistance to scab but it was not affected by scab or other foliage fungus diseases in east central Texas. Sioux is recommended for trial in central Texas and westward, but should not be extensively planted in the humid areas of the Southeast until its scab resistance and production performance is better known.

## B. Diseases

### 1. Pecan.

Scab control. Field tests in Meridian, Mississippi showed that 5 applications (first applied with hydraulic sprayer and subsequent sprays with mist blower) of dodine (Cyprex 65-W) at 1 2/3 lb/24 gallons water was the only treatment giving effective control of scab on the Schley variety. Foliage scab was reduced from 17% on the checks to 5% with Cyprex and scab on the nuts was reduced from 65% to 8%. The percentage of kernel in the nuts averaged 54% in the Cyprex treatment and 46% in the check. Cyprex also effectively controlled scab on the Moore variety but caused severe defoliation after the first application. No conclusions were drawn from these studies because of individual tree variability in the size of the initial crop set. In tests at Fort Valley, Georgia foliage scab failed to develop because of the lack of rain during the early part of the season. Some scab developing on the nuts after excessive rains during June was effectively controlled with one application of Cyprex applied by hydraulic sprayer. At Shreveport, Louisiana field tests on Schley showed as good control with 2 lb/100 of Cr 3025 (coordination product of zinc and manganese ethylene bis dithiocarbamate) as with dodine. Good commercial control was also demonstrated on the same variety with a 4% and 6% dodine dust applied 4 times at the rate of 8 pounds of dust per tree.

In Meridian tests Cyprex used at 2 lb/100 gallons in the hydraulic sprayer, 1 2/3 lb/24 gallons in the mist blower, and 2 pounds in

20 gallons of water per acre applied by airplane all gave effective scab control on Schley and improved the quality of the nuts over those from unsprayed trees. Cyprax caused severe defoliation on the Moore variety but appeared safe on Success and Moneymaker trees. Comparisons of the ground and air applications were inconsistent and inconclusive but will be repeated on larger plots next year. In tests at Cordele, Georgia three applications of Cyprax on Pabst variety gave better control and yield with airplane application than with ground machines. At Melrose, Louisiana 5 aerial applications of dodine (2 lb/20 gallons per acre) resulted in commercial control of scab but was inferior to the same material applied with ground equipment.

Other foliage diseases. At Melrose, brown leaf spot was controlled with aerial applications of dodine while check trees were defoliated. At Cordele, Georgia almost perfect control of powdery mildew resulted from 2 applications of Karathane (2 lb/100) on the Pabst variety. Terramycin treatment continues to effectively control crown gall on pecan trees.

Moneymaker dieback. Soil applications of lime around Moneymaker trees showing dieback resulted in improved growth but the condition has not been eliminated.

Bunch disease. A number of wild species (water hickory, hill land hickory, green ash, hackberry, ironwood, overcup oak, box elder, and elderberry) showing symptoms more or less resembling bunch disease were found in wooded areas adjacent to pecan orchards. There seems to be some evidence indicating the existence of two strains of the bunch virus, one to which the Stuart variety is immune or nearly so, and one to which Stuart is susceptible.

## 2. Walnut.

Bacteriosis. Field spray tests conducted in Oregon comparing (a) a standard hydraulic sprayer, (b) an air-blast spray machine, and (c) a concentrate (turbo-mist) sprayer showed that 3 applications (2 before and 1 after bloom) of bordeaux mixture (4-2-100) and Puratized Agricultural Spray (1 pt./100) were equally effective and best of six treatments. These materials reduced the incidence of infected nuts from 49% to 13% and 12% respectively. Tribasic copper sulfate (3/100), zinc Coposil (4/100), and brown cupric oxide (2/100), although not quite as good as bordeaux, gave a substantial reduction of infected nuts. Bordeaux applied with the turbo-mist (concentrate) sprayer again gave practically as good control as the same material applied with the air-blast spray machine.

Comparative studies of the Howe variety showed for the fourth consecutive year that this variety is resistant to bacterial blight;



only 1.5% of the Howe nuts were affected as compared to 28.8% on neighboring Franquette trees.

Blackline. Trees developed from scions of blackline-affected Franquette topworked on J. hindsii seedlings in 1956 and 1957 continue to appear normal and show no signs of blackline.

Verticillium wilt. A continued attempt to infect J. regia by growing young seedlings in pots of soil heavily infested with microsclerotia of the verticillium fungus isolated from dying maples failed to produce symptoms on either the roots of above ground portions of the inoculated trees, indicating that this rootstock is highly resistant.

### C. Variety Evaluation

1. Persian walnuts. At Corvallis, open-pollinated seedling selections of the Manregian variety were notable for particularly well-filled nuts combined with other desirable horticultural characteristics such as kernel size and quality.

At Roseburg, Oregon, the Moyer variety survived several days of subzero temperatures without injury and produced a commercial crop whereas trees of the standard and leading Franquette variety were winter injured and produced no crop. Moyer, a proprietary variety not currently available to growers, has an upright growth habit and, unlike the Franquette, its nuts dehisce long before the leaves which is a desirable feature.

Seedlings of Manregian and Carpathian walnuts, from seed of three selected sources, are in great demand as rootstocks particularly after the October, 1962, typhoon which uprooted or otherwise destroyed more than 50 percent of Oregon's old mature bearing walnut trees. New plantings indicate that Franquette remains the popular variety although the Hartley is increasing in popularity and Moyer, when available has excellent commercial potential.

2. Pecans. At Meridian, Mississippi selections from Brownwood, Texas and Albany, Georgia, fruited poorly in 1962 and were not evaluated. As in 1960 and 1961, the leaves of Peruque, top-worked on seedling trees, scorched severely in late summer. Peruque branches were nearly defoliated by mid-September, whereas seedling branches on the same trees held their leaves until frost. There appears either to be an incompatibility between Peruque and the seedling stock, or the variety is not adapted to the local soil and climatic conditions. Peruque is a proprietary variety originated from unknown parentage at St. Charles, Missouri and introduced commercially in 1953.



3. Filberts. Evaluation of filbert selections and varieties in Oregon showed 17 of 31 studied to have a higher kernel percentage than the leading commercial variety Barcelona. Three old varieties and 8 selections had very high kernel percentages, 45 percent or better, and were productive but their tendency to produce relatively small or elongated nuts complicate their acceptance by an industry based on the larger and rounded Barcelona kernel.

#### D. Culture.

##### 1. Almond.

Pollination and fruit set. Almond requires set of at least one-third of its blossoms to produce a good commercial crop whereas deciduous fruit crops require only a 3-5 percent set and then fruit thinning is required. Pollination of and by commercial varieties currently being grown tends to be inadequate and the cross pollination ability of varieties and selections are now being tested at Fresno to improve fruit set of almond.

Rootstocks. The principal rootstocks for almond are almond and peach. Nemaguard, a new peach-like nematode-resistant rootstock developed mainly for peach, was superior as a rootstock for almond and particularly in almond areas of the San Joaquin Valley.

##### 2. Filbert.

Storm damage repair. The typhoon that struck the Pacific Northwest in October, 1962, uprooted an estimated 35 percent of the mature filbert trees in Oregon. Growers were advised to reset trees by straightening and propping them, and then pruning the tree head somewhat heavily to offset root loss as well as reduce wind resistance. A subsequent severe windstorm in March, 1963, again uprooted reset trees not staked and pruned as recommended.

Pruning. Although storm damage precluded precise records, indications were that the rejuvenation pruning of crowded filbert trees in old established orchards continued to alleviate the previously characteristic alternate bearing habit.

Spacing. In the study in which trees were planted at distances of 15 x 15, 20 x 20, and 25 x 25 feet respectively, 3-year-old trees at the closer spacing produced the highest, and trees at the most distant spacing produced the lowest, yield per tree and per acre. There was no effect of spacing on nut size.

Blank nuts. Pollination was not a factor of blank-nut production at Corvallis. Potassium fertilizer application tended to reduce the number of blank nuts developed by 4-year-old trees. Trees receiving no potassium yielded 13 percent, whereas trees receiving potassium produced only 4 percent, blank or unfilled nuts.

Nutrition. In Oregon, trees in a factorially designed experiment, using 3 levels each of phosphorus and potassium, fruited for the first time but results were obviated by storm damage.

In another test of 11 different fertilizer materials, the highest yielding 4-year-old trees received 10-16-8 analysis fertilizer and the lower yielding, in addition to the checks, were trees receiving no potassium. In previous experiments with old trees, potassium effectively increased nut size but potassium applied to the younger trees of the current experiment had no effect on nut size.

### 3. Pecan.

Orchard establishment. An experiment was started in Louisiana in 1950 to determine the relative merits of planting seeds at permanent orchard locations and grafting them in place compared to the use of grafted nursery trees. Although total yields in 1962 were reduced 80%, compared to 1961, the current yield data continue to support the earlier demonstration of a superiority of trees grafted in the nursery and attributed to initially older and bigger trees from the nursery. Cost of seedling and special care of the in-place grafted trees negated the premium paid for nursery trees.

Cover-crop management. At Albany, Georgia, a study of cover-crop management comparing mowed cover crop versus summer cultivation, started in 1954, was terminated in 1962 after 6 years of tree productivity. Summer cultivation caused high acidity and vetch and other leguminous cover crops failed until the acidity was corrected by liming. There was no effect of cover-crop management on yield of nuts which indicated that deep-rooted pecan trees are insensitive to major changes in surface soil which otherwise affect plants having shallower root systems.

Nutrition. A 10-year fertilizer experiment with Schley pecan on Yohola loam soil in Caddo Parish, Louisiana, has been terminated. The 2 x 2 x 2 factorial NPK experiment used ammonium nitrate, triple superphosphate, and potassium chloride as sources of the key elements. During the experimental period, phosphorus penetrated to an 18-inch depth and phosphorous was taken up by the leaves in all years except the first. Although potassium penetrated to a 30-inch depth, leaf analysis showed an increased potassium uptake unexplicably only during 1960. Thus factors, other than soil penetration and availability, are governing potassium uptake by pecans.

At Meridian, Mississippi, Success and Moneymaker pecans were fertilized with 2 levels each of nitrogen and potassium in split plot studies of sod and cultivation. The Moneymaker trees produced a higher yield at the high nitrogen-potassium level in cultivated plots, and at the low nitrogen-potassium level in the sod plots. The cultivated trees produced a higher average yield than did trees in sod. There were no effects of treatment on yield of Success trees which were in their "off" year during 1962. As in 1961, there was no effect of treatment on nut size, percentage of kernel, or kernel quality.

Biochemistry. In 1961, the oil content was reported to be consistently higher in nuts from trees receiving no nitrogen, than from trees receiving, supplementary nitrogen. During 1962, nuts from the above 1961 crop were analysed and found to contain the following fatty acids: palmitic, palmitoleic, stearic, oleic, lonoleic, and linolenic. Oleic acid content was higher, and linoleic acid content lower, in kernel oil of nuts produced by trees receiving high nitrogen in the soil.

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WEED AND NEMATODE CONTROL  
Crops Research Division, ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, increase production efficiency and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations cultural practices, chemicals and biological methods on deciduous fruits and tree nuts.

USDA PROGRAM

Much of the weed control research in the Department is cooperative with State Experiment Stations, other Federal agencies, industry and certain private groups, and is cross commodity in nature. The total weed control program involves 66.5 professional man-years' effort. Of this total, 0.3 is specifically directed to weed control in deciduous fruits at New Brunswick, New Jersey and Beltsville, Maryland.

The Federal scientific effort devoted to basic and applied nematode research is 21.5 professional man-years, of which 0.7 is devoted to research on deciduous fruits and tree nuts at Baton Rouge, Louisiana and Logan, Utah.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Weed Control

1. Physiological and Ecological Studies. Interest in weed research on fruits and nuts continues to be centered on the physiological effects of repeated long-term use of effective herbicides in these perennial crops. Research based on need for basic information on these effects initiated in 1960 at New Brunswick, New Jersey, is being continued. It includes studies on blueberries, cranberries, apples and peaches.

2. Control Studies. Apples - In studies initiated in 1960 at New Brunswick, New Jersey, diuron, simazine, CIPC, and diuron + CIPC have been compared to plastic mulch and clean cultivation for control of weeds. Though it is too early to obtain fruit yields, annual trunk diameter measurements are assuming a trend toward significant differences in growth rate in the various treatments.

Blueberries - At New Brunswick, New Jersey, repeated use of diuron, simazine, diuron + CIPC, diuron + DNBP, and CIPC beginning in 1960 have not reduced yields or fruit quality nor have foliar or growth injury symptoms appeared. Annual broadleaved weeds and weed-grasses characteristically controlled by the herbicides were controlled in these experiments.

Cranberries - Studies were conducted on the control of chain-fern (Woodwardia virginica), weed-grasses and sedges in cranberries at New Brunswick, New Jersey, using granular dichlobenil and CIPC. Dichlobenil appeared highly promising on the control of chain-fern but further research is needed to confirm this result. The CIPC was not effective in controlling the grasses and sedges.

Peaches - Experiments begun in 1960 at New Brunswick, New Jersey, include annual applications of diuron, simazine, CIPC, diuron + CIPC, and dalapon compared to clean cultivation and handweeding. Growth was not affected nor were injury symptoms observed in any of the treatments. Differential varietal responses were not evident in any of the treatments. No residue was found in peaches treated with simazine for two years.

Strawberries - Though many herbicides have been evaluated on strawberries, those in current commercial use may be, in general, considered as stopgaps. The need for improved weed control methods for strawberries continues to be felt. In research at Beltsville, Maryland, culmination of a two-year experiment on the use of EPTC and its analogs including R-1607, R-1870 and R-2061. Of these, R-1870 appears most selective on strawberries based on yields and injury ratings.

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##### Weed Control

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## INSECT CONTROL

### Entomology Research Division, ARS

Problem. Insects and mites are important limiting factors in the production of high quality fruits, nuts, grapes and berries. These pests shorten the profitable life of the trees, vines, or plants, and reduce the yield or lower the quality of the crop. Certain insects and mites transmit diseases that affect adversely the life and productivity of the host plant. No one method of control is fully satisfactory and methods that are effective now may not be so later. Biological, cultural and other non-chemical methods of control are only partially effective. Consequently, dependence must be placed on insecticides for control. The continued use of insecticides, however, is complicated by the occurrence of insecticide-resistant strains of an increasing number of insects and mites, by the need to avoid objectionable residues on fruits and berries and on their waste products used for livestock feed, by their detrimental effects on beneficial insects, fish and wildlife, and by contamination of non-target areas. There is a continuing need for research to develop more selective, economical and safer insecticides; and an urgent need, because of growing concern over the use of insecticides, for intensified research on alternative types of control such as those based on the use of attractants, repellents, traps, insect-resistant varieties and growth-affecting materials, including chemosterilants. More research is needed on integrated chemical-biological control programs with emphasis on less intensive spray programs, so that the maximum benefits from parasites, predators and pathogens may be realized. Research is required to determine more fully the role of insects in the transmission of important diseases affecting the production of these crops, to discover the insect and mite vectors of the diseases and to determine their host preferences, ranges, and habits. Means must then be developed to reduce or eliminate the vector populations responsible for spread of the diseases.

### USDA PROGRAM

The Department has a long-term program involving entomologists, chemists, insect physiologists, and insect pathologists engaged in both basic studies and practical solution of grower's problems. Research on pome and stone fruit insects is carried on at Yakima and Wenatchee, Wash., Vincennes, Ind., Wooster, Ohio, Kearneysville, W. Va., and Fort Valley, Ga., in cooperation with the respective State Experiment Stations. Research on insects and mites affecting pecan production is carried on at Albany, Ga., and Shreveport, La.; on insects affecting the production of grape, blueberry and black walnut at Wooster, Ohio, in cooperation with the Ohio Experiment Station; and on berry insects at Beltsville, Md., and Riverside, Calif., the latter in cooperation with the California Experiment Station. Research on insects and mites in relation to the transmission of diseases of deciduous tree fruits is carried on at Riverside, Calif., Corvallis, Oreg., Wenatchee, Wash., and Fort Valley, Ga., in cooperation with the

respective State Experiment Stations and the Crops Research Division.

The Federal scientific effort devoted to research in this area totals 21.1 professional man-years. Of this number 2.4 is devoted to basic biology and nutrition; 5.6 to insecticidal control; 3.4 to insecticide residue determinations; 0.6 to biological control; 3.3 to insect sterility, attractants, and other new approaches to control; 1.0 to evaluation of equipment for insect detection and control; 3.5 to insect vectors of plant virus diseases; and 1.3 to program leadership.

Additional research (3.5 professional man-years) is in progress under grants of P.L. 480 funds to the Institute of Pomology, Skierniewice, Poland, for studies of the differences in susceptibility and in cholinesterases in various species of spider mites as influenced by acaricides and for studies on the biological control of aphids and scale insects on deciduous tree fruits and effects of pesticides on natural enemies. A portion of a grant of P.L. 480 funds to the Commonwealth Institute of Biological Control, Rawalpindi, Pakistan (10 professional man-years) for research on scale insects, fruit flies, and mites, and their natural enemies in West Pakistan is applicable to insects affecting deciduous tree fruits.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Basic Biology and Nutrition

1. Deciduous Fruit and Nut Insects. Limited studies of the biology of the pear psylla, blueberry tip borer, cherry fruitworm, mirids that feed on pecan, periodical cicada and lesser peach tree borer were made as a basis for improving or developing more appropriate control recommendations. Continued study of the movement of the pear psylla in Washington confirmed previous findings that this insect migrates mostly during the fall and early spring months. Psylla adults overwinter on fruit trees other than pear and on plants growing considerable distances from the pear orchards in which the psylla were produced. In the spring these psylla may move to pear orchards located some distance from the orchards in which they were produced. In Ohio information was obtained on the seasonal history and habits of the blueberry tip borer and cherry fruitworm in blueberries as a basis for determining the status of these insects as pests and for developing control recommendations. In the South several species of mirids, particularly Neolygus caryae and Plagionathus ablutus, sucking insects which appear in large numbers on the developing pistillate bloom of pecans, have been thought to be responsible for loss of young nuts on which they feed. In Georgia these mirids laid eggs in terminal growth and fed to some extent on small nuts as well as on leaflets and new terminal growth, but preliminary tests indicated they are not responsible for crop losses.

In studies of the periodical cicada in Indiana it was found that the adults of this insect moved into orchards from surrounding woodlands when the urge to oviposit reached a peak. The cicadas were able to lay numerous



eggs before they were killed by insecticide applications to the orchards. This emphasizes the need to treat surrounding woods before cicadas move into orchards. It was also found that the lesser peach tree borer starts to emerge about a month earlier than formerly believed, indicating that control measures should be initiated earlier than commonly recommended. In West Virginia analyses of sprayed apple leaves showed that spray schedules containing DDT or carbaryl (Sevin) were followed by consistently higher levels of leaf sugar in the leaves than spray schedules containing other materials. This condition was correlated with higher mite populations.

It is essential that large numbers of test insects be available at all seasons of the year to facilitate the conduct of an uninterrupted research program. To raise normal insects cheaply and in large numbers requires knowledge of their physical and nutritional requirements. In Indiana an artificial diet that was inadequate for the production of normal codling moths became satisfactory when ascorbic acid was added. Studies to adapt this diet to large-scale laboratory production of the codling moth are underway. In Washington production of the codling moth was increased from 1.2 cocoons per thinning-size apple to 5 by cutting the thinning-sized fruits into quarters or eighths and coating the sections with paraffin to prevent their premature decay. Preliminary studies of diets for rearing the hickory shuckworm, pecan leaf casebearer and fall webworm, to provide a continuous supply of these insects for studies on their control on pecans in Georgia were unfruitful. Ability to mass produce insects is a prerequisite for research on the sterile male release method of population suppression.

2. Insect Vectors of Viruses. At Corvallis, Oreg., biological studies were conducted with Scaphytopius acutus, an established leafhopper vector of X-disease virus of stone fruits. The object was to determine whether there are two strains of this species, one obligated to enter diapause during the winter and the other capable of breeding continuously. Critical taxonomic study showed that the leafhopper not requiring a diapause was another species, Scaphytopius delongi, that occurs frequently in populations with S. acutus. The fact that S. acutus has been handled in pure culture in many or most instances in the past indicates that it is a vector of X-disease. The status of the newly detected S. delongi needs to be investigated.

In California a repetition of an early summer survey for the peach mosaic transmitting eriophyid mite, Eriophyes insidiosus, in the central part of the State again indicated that the vector is not present in that area. Thus, the known range of the vector is south of districts producing the preponderance of California's peaches. Less than 2,500 acres of 118,000 commercial peach acres in California are in the territory known to be infested by the virus-carrying mite.



Several species of eriophyid mites in the genus Eriophyes related to the demonstrated mite vectors of peach mosaic and cherry mottle leaf viruses have been detected. These have been found on stone fruit trees, including wild, native Prunus, pear, apple, and several species of perennial plants in the proximity of stone fruit orchards. The mites are being described and named. They deserve attention in future studies that may be initiated to find vectors of several other deciduous fruit tree viruses.

## B. Insecticidal Control

1. Codling Moth. The demonstrated ability of the codling moth to develop resistance to insecticides is responsible for the need to continue studies of promising new insecticides and studies that may lead to the more effective integration of chemical and non-chemical methods for controlling this insect.

Guthion and carbaryl alone or in combination continued to give effective codling moth control. None of the new materials tested in field plots in Washington and Indiana and bioassayed in the laboratory was equal or superior to these materials. However, Bayer 39197, 41831 and 47940, General Chemical GS-3707, Thiodan II, and Stauffer R-3413 gave economic control in orchard plots in Washington; and American Cyanamid 38023, Bayer 44646 and 37344, and Zectran gave good control in field-laboratory tests in Indiana. In Indiana there was an indication that the carbamates, Bayer 37344 and Zectran, would reduce the set of apples when applied at or within 30 days after petal fall. In laboratory screening tests in Washington and Indiana 13 compounds were found worthy of further study. Of these Bayer 41831 and 46676, General Chemical CPD-4072, Hercules 7845C and Monsanto CP-40507 were superior to Guthion in toxicity to newly hatched codling moth larvae. In tests in Indiana the addition of summer oil increased the effectiveness of carbaryl against the codling moth.

Increasing support is being obtained for the idea that less intensive spray programs than those now commonly recommended may give adequate control of the codling moth and associated insects. Further studies in cooperation with commercial apple growers in the Yakima Valley, Wash., showed for the third consecutive year that economic control of codling moth and mites may be possible with two applications of Guthion and an acaricide. In an orchard in Indiana in which the 1961 crop averaged 176 worm holes per 100 apples, Guthion spray programs reduced the number of worms to less than 1 per 100 apples in 1962. Lengthening the interval between applications after the second cover spray from 10 to 16 or 26 days resulted in little loss in effectiveness. Fruit free of insect injury averaged 99.5% in the block sprayed 11 times at 10-day intervals, 96.4% in the block sprayed 8 times at 16-day intervals, and 93.5% in the block sprayed 6 times at 26-day intervals. In the last block injury due to the codling moth amounted to only 0.9 worm and 4.9 stings per 100 apples.

In continued studies of the effectiveness of concentrated sprays for controlling codling moth on apple, 12 pounds of 25% Guthion wettable powder per acre applied in 800, 400, 200, 100, and 50 gallons per acre with a conventional air blast sprayer, and in 60 gallons per acre with a sprayer designed for concentrate spraying, were equally effective in controlling the codling moth in the Yakima Valley in Washington. Chemical analyses for Guthion residues on foliage following spray applications showed that deposits at the 6-, 12- and 18-foot heights were comparable at application rates of 800 and 400 gallons per acre. When application rates were decreased to 200, 100 and 50 gallons per acre, deposits at the 18-foot height remained about the same but at 6- and 12-foot heights there was a gradual increase with decreases in gallonage.

2. Orchard Mites. Strains of orchard mites resistant to approved miticides are widespread. None of the recommended materials can be depended on to control all strains. This situation has required an accelerated program of screening of new insecticides, antibiotics, and other types of compounds that might inhibit mite activity and development and an intensification of studies of factors responsible for fluctuations in mite populations.

In orchard tests in the Yakima Valley, Washington, Kelthane and tetradifon, the standards for comparison, gave effective control of the mcdaniel mite, the predominant species on apple. Miticides OW-9, Moricide, and Bayer 36205 were equal to or superior to Kelthane or tetradifon. Bayer 47185 was practically equivalent to the standards. Fair control was obtained with Volck Supreme oil and its effectiveness was not increased by the inclusion of tetradifon. Other materials were ineffective. Bayer 36205 caused some injury to apple foliage. In laboratory screening tests 11 of 59 compounds were worthy of further study.

Field tests in Indiana on apples during the prebloom and early cover spray period showed that a pink-bud application of chlorbenside or two applications of tetradifon, in the first and second cover sprays, were highly efficient--more so than a spray at greentip that contained oil. Tetrasul applied at the pink-bud period was as effective as chlorbenside or tetradifon. Dimite applied at the pink-bud stage was not commercially effective. Indopol polybutene and polypropylene, materials that leave tacky deposits which trap the mites, continued to offer promise for early season mite control but in some tests they caused extensive phytotoxicity. These materials are most promising for use in early postbloom applications. Another sticky substance that shows considerable promise is Foxlene, a by-product of rosin from pine trees. Root zone injections of phorate at the pink-bud period have provided excellent mite control in numerous tests. In other tests residues of phorate were translocated to the leaves but not to the fruit. Similar applications of Di-syston were also effective.

Field comparison of miticides at Vincennes during mid-July showed that it would be advisable for growers to apply two sprays at 7-day intervals, rather than to rely on one application. The more effective miticides for



use in such a schedule included binapacryl, Kelthane, Naugatuck OW-9 and C-417, and Union Carbide 20047. American Cyanamid EI-43064 and dimethoate, while less effective, also gave good control. A number of new compounds were found worthy of further study as the result of laboratory screening tests.

In West Virginia, dimethoate and Zectran were effective summer miticides when used in repeated applications. There was an indication that the number of current cover sprays recommended could be reduced, possibly to five, in most orchards and still give adequate mite and insect control.

The European red mite and two-spotted spider mite were problem pests on both apples and peaches in Ohio. As in Indiana two closely spaced applications of a miticide gave much better control during the summer than a single application. Imidan, Hooker 16-A, and Indopol polybutene H-100 were less effective against the two-spotted spider mite than against the European red mite. A mixture of ethyl-methyl Guthion, Shell 3562, American Cyanamid 43064, Bayer 36205, Animert, GC-3707, phosphamidon and dimethoate gave promising results against both species on apples and/or peaches. Three or more consecutive sprays or heavy dosages of Indopol polybutene H-100 caused leaf yellowing and drop. Bayer 36205 also caused some spotting on Rome and Cortland apples.

In orchard plot studies of concentrated acaricide sprays for control of mcdaniel mite on apple in Washington, good control was obtained with 800 and 400 gallons of spray per acre while poor control was obtained with 200 gallons or less applied with a conventional air blast sprayer and with 60 gallons per acre applied with an air blast concentrated sprayer.

Studies of the translocation of toxicants in deciduous trees at Wenatchee, Wash., made by administering various compounds in solution through small holes (with brass coupling) in the trunk or large branches, showed that Meta-systox, Dylox, Bidrin, DDT, and dimethoate administered to mature cherry trees, was readily translocated to leaves in various parts of the tree where they caused considerable mortality of the two-spotted spider mites during several weeks. Bidrin killed 89% of the mites one month after introduction into the trees. Dimethoate and Acti-dione translocated in peach trees had a marked effect on the peach silver mite population.

In Poland under P.L. 480 project E21-ENT-5 research efforts to develop a malathion-resistant strain of the two-spotted spider mite by selective treatments were unsuccessful and a search is now underway for naturally occurring resistant strains. This confirms experience in the United States that no case of high resistance in mites has been developed in the laboratory by acaricide pressure applied to a non-resistant colony. Strains of Bryobia praetiosa resistant to organic phosphate insecticides failed to survive low winter temperatures, -39° C., while nonresistant strains survived. Under the low temperature conditions 90% of the European red mite overwintering eggs were killed.



3. Plum Curculio. Parathion, Guthion and dieldrin are the most commonly used insecticides for controlling this insect. Parathion and Guthion are hazardous to handle and dieldrin can be used only in the early part of the season. It is important that the search for safer materials which can be used throughout the season be continued.

In orchard experiments, in Georgia, Bayer 25141 and Bayer 37344 were superior to parathion for protecting peaches from the plum curculio. Imidan, dimethoate and Zectran were less effective than parathion. Bayer 25141 and dimethoate caused foliage injury. In laboratory screening tests against plum curculio adults U. S. Industrial Chemical Co. 781-219B gave excellent initial kill but it had poor residual value. Bayer 44646 was ineffective.

In orchard spraying experiments in Ohio, Bayer 37344, Sumathion, American Cyanamid 43064, and Imidan reduced the number of curculio larvae that emerged from dropped plums by more than 99%. Unsprayed trees produced 537 curculio larvae per tree.

There is an indication that soil in heavily sprayed peach orchards is becoming toxic to plum curculio grubs. In Georgia where 322 of 400 grubs emerged as adults when placed in soil from an unsprayed, uncultivated field only 14 of 400 emerged from soil from an orchard that had been sprayed for a number of years with benzene hexachloride and only 85 of 400 from soil from an orchard similarly sprayed with parathion, except for one application of dieldrin in 1962.

Chlorinated hydrocarbon insecticides applied to the soil at 2 or 4 pounds per acre in Georgia were effective in preventing the development of plum curculio grubs from developing into adults. Tests of such treatments applied in more northern areas indicated that the residues there were less effective. Soil applications of aldrin at 3 to 5 pounds per acre in Indiana and Kentucky and of dieldrin at 6 pounds per acre in New Jersey failed to give satisfactory reductions in adult emergence. In a laboratory test in New Jersey 6 pounds of dieldrin per acre prevented adult emergence, indicating that migration of curculios from outside of the dieldrin-treated test orchard may have been a factor in the poor results obtained.

4. Deciduous Tree Fruit Borers. The peach tree and lesser peach tree borers are considered in some areas to be the most serious pests of peaches and, to a lesser extent, other stone fruits. In a comparative test in Georgia, endrin in a single application to the trunks of peach trees early in July or in two half-strength applications, one early in June and one early in August, gave nearly complete control of the peach tree borer. Similar applications of endosulfan and dieldrin were about equally effective and only moderately less so than endrin. In Indiana a single application of endosulfan to the trunks and scaffold limbs of peach trees at  $2\frac{1}{2}$  pounds per 100 gallons of water early in June prevented the development of severe infestations of the lesser peach tree borer and

3 applications to all parts of the trees at  $3/4$  pound per 100 gallons kept injury by this borer to a low level.

5. Pear Psylla. Increased emphasis has been given to the control of this insect because of its increasing resistance to summer spray treatments and its possible relation to the spread of pear decline in the West.

In experimental plots at Yakima, Wash., three or four summer applications of Guthion gave good control of the psylla but there was evidence of gradually increasing resistance to Guthion. Bayer 36205 was more effective than Guthion but caused some discoloration of pear leaves. Imidan, Zectran, and half-strength Guthion with summer oil gave control equal to that obtained with Guthion at the standard strength of  $1\frac{1}{2}$  pounds 25% wettable powder per 100 gallons of water. Guthion 25% wettable powder, 9 pounds per acre applied in 600, 300, 150 and 75 gallons per acre, with an air blast sprayer that delivered 44,000 cubic feet of air per minute, was equally effective in controlling pear psylla regardless of the quantity of solution applied per acre. Results were less satisfactory when Guthion was applied with a sprayer designed for the application of concentrated sprays, which produced about one-fourth the volume of air produced by the conventional sprayer.

Orchard tests of materials applied during the delayed dormant period in Washington showed that the standard oil ( $1\frac{1}{2}$  gallons)-lime sulfur (3 gallons per 100 gallons of spray) treatment is highly effective for controlling the pear psylla. Morestan (Bayer 36205) gave results equivalent to the oil-lime sulfur spray. Volck Supreme oil  $1\frac{1}{2}$  gallons per 100 gallons also gave good results but it was less effective when lime sulfur was included. The effectiveness of an oil spray was not increased by the addition of ethion. Indopol polybutene (H-100) was ineffective.

Pre-pink (cluster bud) sprays of Perthane, Dilan, or Guthion were about equally effective in controlling pear psylla. Indopol polybutene (H-100) was again ineffective. In general, the pre-pink sprays were slightly less effective than delayed dormant sprays.

In laboratory screening tests of 51 materials against pear psylla at Wenatchee, Wash., only Shell SD-8280, General Chemical 4072, Union Carbide 21149, and Bayer 47043 caused greater mortality of pear psylla than Guthion, the standard material. Most of the remaining materials were less effective than the standard.

6. Miscellaneous Insect Pests of Deciduous Tree Fruits. The apple maggot is a serious pest of apples in the northeastern States and northern portion of the Midwest. In Ohio a soil application of endrin at 5 pounds per acre in the spring did not materially reduce the subsequent season's apple maggot fly population or fruit infestation.



Sucking bugs that cause deformed peaches are often responsible for larger losses of peaches than any other insect. There is need for an insecticide that will be highly effective against these insects. In orchard tests in Indiana good control of sucking bugs was obtained with Imidan, carbaryl, Guthion, parathion, Zectran, Bayer 37344 and endosulfan.

The occurrence of TDE-resistant strains of the red-banded leaf roller and lack of agreement on the value of substitute materials for TDE are the basis for a continuing search for more suitable materials for the control of this insect. In field-laboratory and laboratory screening tests in Indiana, 20 new compounds gave good to excellent control of this leaf roller, the most promising of which included carbaryl, Imidan, Zectran, Bayer 37344, Monsanto CP-40294, American Cyanamid EI-43064, Stauffer N-2404 and N-2793, Ciodrin, and Niagara 9203. These materials require further evaluation in more critical tests.

Scale insects continue to increase to an injurious level whenever control measures are relaxed. In tests against a heavy infestation of the San Jose scale on apple in Indiana certain organic phosphate insecticides, particularly parathion, used in several cover sprays gave better scale control than an oil spray alone or when applied with an organic phosphate insecticide at prebloom. Two carbamate insecticides, Bayer 37344 and carbaryl, were especially effective. In Georgia Imidan, diazinon or ethion in two applications late in the summer did not control the white peach scale, a confirmation of the ineffectiveness of summer sprays recorded for the control of this insect in previous experiments.

In Ohio dormant spray applications were ineffective in controlling the blueberry tip borer but two post-bloom applications of malathion or carbaryl or a combination of the two materials gave effective control of this borer as well as of the cherry fruitworm in blueberries.

7. Pecan and Other Nut Insects. Progress continued to be made in studies to develop basic knowledge of the ecology and biology of the more important insect pests of pecans and methods for combatting them. In a field experiment in Georgia EPN alone was as effective in controlling the hickory shuckworm as when used in combination with an adhesive. Two applications of EPN were as effective against a light shuckworm infestation as three applications.

There is need for an insecticide other than a chlorinated hydrocarbon to control the pecan weevil in groves used for pasture. In tests in Georgia, carbaryl, EPN, and Guthion were as effective as DDT against a light infestation of the weevil. Preliminary results of cage tests of soil applications of aldrin, dieldrin and heptachlor at 5 pounds per acre to control the weevil before it emerges were not encouraging.



The occurrence of the pecan leaf casebearer in outbreak numbers in the Southeast the last few years has presented an opportunity to develop improved measures for its control. In Georgia spring applications of Guthion, EPN, or parathion were more effective than those of malathion or Sevin. However, summer applications of insecticides, because of the wider latitude for their timing, have proved to be superior to spring applications.

There is some question concerning the effect of mirids on setting of the developing pistillate bloom in the spring. If the present investigations show that their feeding is responsible for significant crop losses, they may be easily controlled by applications of malathion, parathion, Guthion, or Sevin, as shown by tests in Georgia.

The fall webworm is widespread throughout the pecan producing area. Parathion and Zectran gave nearly complete control of this pest in tests in Georgia and were superior to endosulfan, carbaryl, demeton and malathion as well as to a variety of experimental insecticides.

In an exploratory test in Indiana a malathion-protein hydrolysate bait spray in two applications gave nearly complete control of the walnut husk maggot, a common pest of Persian and black walnuts and butternuts throughout the eastern United States. The result was an average of 75 pounds of nuts per tree instead of a total crop failure as in other recent years.

8. Grape Insects. The grape berry moth, potentially the most serious pest of grapes, was generally not present in injurious numbers during the year. Research conducted on light infestations in Ohio showed that control of grape berry moth was adequate where DDT plus parathion, carbaryl, or Zectran had been used.

Injury to Concord grapes by the grape cane girdler has increased in the Ohio grape belt during the last five seasons. Information on the life history, activity, and pest status of this insect is limited. In Ohio results of spray tests indicated that applications should start during the prebloom period for most effective control. Guthion applied at petal fall and in two subsequent cover sprays gave very good control and was superior to carbaryl. The latter in turn was superior to a combination of malathion with DDT.

### C. Insecticide Residue Determinations

1. Deciduous Tree Fruits and Nuts. Residue studies on some of the newer insecticides in Indiana, Ohio, and Washington showed (1) three postbloom applications of 12 ounces binapacryl per 100 gallons of spray to grapes in Ohio left residues of only 0.1 p.p.m. on the grapes 30 days after the final application; (2) in Indiana the magnitude and persistence of residues of tetradifon on apple leaves were increased by the addition of polybutenes; (3) the addition of oil to summer spray mixtures containing carbaryl reduced the initial deposit of carbaryl on apple foliage and fruit

while the addition of polybutene increased the deposit of carbaryl on foliage but not on fruit; (4) Guthion residues on apples at harvest following one to ten applications in Indiana were less than 0.7 p.p.m. 7 days after the final spray; (5) in Indiana harvest residues of Zectran on peaches sprayed with 1 pound Zectran in 7 postbloom applications were 2 and 0.95 p.p.m., respectively, 7 and 14 days after the final application; on apples that received 6 applications of Zectran there was no detectable residue on samples taken 3 to 21 days after the final application; (6) in Indiana lead arsenate residues on apples at harvest were increased by 100% when polybutene was included in the spray mixture before or after the application of lead arsenate; and (7) apples treated with 1 pound Imidan per 100 gallons in 6 cover sprays contained 0.8 and 0.6 p.p.m. of Imidan, respectively, 1 and 14 days after the final application and peaches receiving 7 similar applications contained 0.8 and 0.4 p.p.m, respectively, 15 and 21 days after the final application.

In Indiana soil treated in 1944 with approximately 2300 p.p.m. DDT was sampled in layers to a depth of 25 inches in January 1962. Analyses showed the presence of about 600 to 1000 p.p.m. of DDT remaining.

#### D. Biological Control

1. Deciduous Fruit and Tree Nuts. Efforts to utilize the DN-136 nematode and associated bacterium to control the codling moth were continued in West Virginia with negative results. While it was again confirmed that the nematode destroys many of the codling moth larvae that cocoon in bands on the tree trunks, the nematode, which is very susceptible to dryness, does not appear able to survive and maintain itself in sufficient numbers in the upper parts of the trees to provide effective control of codling moth larvae.

In Pakistan, under P.L. 480 Project A17-ENT-5, an intensive survey for scale, fruit flies and mites and their natural enemies was carried out in four zones divided in accordance with topography, climate and host picture. The many species collected and reared are now being evaluated to provide a basic list for more intensive study to determine what, if any, beneficial species are worthy of colonization in the United States. Of particular interest was the recording of 19 species of predators of mites, of which 10 were previously unknown in Pakistan. Preliminary indications are that some of these mite predators may be worthy of importation into the United States for colonization. Identification of the many species collected has been a problem but is gradually being accomplished.

In Poland, under P.L. 480 project E21-ENT-2 studies on the biological control of aphids and scale insects and the effects of pesticides on the natural enemies of these pests have provided a list of the injurious and beneficial forms present in the study area and provided the basis for their classification in order of importance. Future studies will be concentrated on the more important injurious species and on the beneficial



forms of greatest possible usefulness. Tar oils and organic phosphate insecticides applied to control the European fruit lecanium scale reduced populations of the scale in the range of 77-82% and those of the two most important scale parasites to about the same extent. In the laboratory five organic phosphorus insecticides were toxic to the predatory lady beetle, Coccinella quinquepunctata, but not all to the same extent, methyl parathion and malathion being the most toxic of those tested. Data on Chrysopa spp., aphid predators, showed that they destroyed from 108 to 521 aphids each during their larval development period. Honeydew was an important part of the diet of these lacewings, influencing markedly their ability to lay eggs.

2. Berry Insects. The spider mites, Tetranychus telarius and T. atlanticus, are serious pests of strawberries in the eastern United States. Insecticides are erratic in effecting their control and apparently have a detrimental effect on their common predators. In a planting sprayed with Kelthane in the fall of 1962 and early spring of 1963, the mite population increased considerably in May then began to decline. Examination of infested leaves May 31 showed a high population of the predatory mite, Amblyseius fallacis, and a low population of T. telarius. The predatory mite had destroyed virtually all the mite eggs as they were laid. An application of malathion shortly after the above examination killed off most of the predators with the result that the population of T. telarius increased and caused foliage injury during June.

#### E. Insect Sterility, Attractants, and Other New Approaches to Control

1. Deciduous Fruit and Tree Nut Insects. The sterilization of insect populations by radiation or with chemicals as a means of control or eradication received increased attention during the year. This approach to control offers one possible means of reducing dependence on conventional insecticides. In Washington studies of the effect of gamma irradiation on codling moth stages indicated that eggs are more susceptible to injury from irradiation than pupae. The latter are more susceptible to injury than adults. The irradiation of adults with 30,000 roentgens caused complete sterility of females. Only 1% of the eggs from normal females mated with irradiated males produced normal progeny. When irradiated moths were placed in cages at the rate of 10 treated males, 10 treated females, 1 normal male, and 1 normal female, less than 1% of the eggs deposited produced moths. Moths sprayed with tepa, a chemical sterilant, were also sterilized, indicating a possibility that chemicals may provide a more effective means of sterilization than gamma radiation. None of the eggs hatched when nontreated males and females were mated with moths that had been sprayed with 3 and 5% solutions of tepa. Only 5% of the eggs hatched when nontreated moths were crossed with moths sprayed with a 2.5% solution.



Twenty-two antibiotics tested on the two-spotted spider mite at Wenatchee, Wash., by applying them to greenhouse plants, revealed only three, Pleomycin, Venturicidin, and Hygromycin B, that caused 90% or more mortality.

In Indiana, chemosterilant activity was obtained with apholate against two-spotted spider mites on lima bean plants in laboratory tests at levels between 0.05 and 1.0%, but the 1.0% level was phytotoxic to the bean plants. Allethrin acted as a chemosterilant when used at 16 and 32 ounces per 100 gallons but was also phytotoxic to the bean plants.

In Georgia, tepa, apholate and tretamine showed definite possibilities for use as sterilants of both sexes of plum curculio adults. Mortality was high in all groups of adult curculios injected with or dipped in these materials.

The female moths of certain insects contain a powerful male sex attractant. In Georgia caged virgin female peach tree borer moths or extracts from such moths attracted numbers of male peach tree borer moths. In Indiana similar results were obtained with lesser peach tree borer moths. The next step is to produce or obtain moths in sufficient numbers to provide enough insects or extract of the attractant so that a toxicant-attractant combination can be tested on orchard populations of these borers as a means of direct control through annihilation of males. The chemists also need sufficient material from female moths for identification of the chemical and development of a synthetic product. In Georgia no response was obtained when extracts prepared from male and female pecan leaf casebearers were exposed to orchard populations. Black light traps, however, were attractive to both leaf casebearer and hickory shuckworm adults.

In Ohio a liquid bait composed of a protein hydrolysate and ammonium phosphate was generally superior to ammonium carbonate or a mixture of glycine and sodium hydroxide for attracting the apple maggot, cherry fruit flies, or the walnut husk maggot. In Indiana ammonium carbonate proved to be a practical lure for the walnut husk maggot.

#### F. Evaluation of Equipment for Insect Detection and Control

1. Pecan Insects. In Louisiana it was again demonstrated that aerial applications of demeton or malathion give good control of the black pecan aphid. An aerial application of benzene hexachloride also gave good control of the pecan phylloxera; however, two applications may be necessary when pecan varieties in an orchard do not foliate at or near the same time. Further tests of aerial applications of insecticides to control the pecan nut casebearer again demonstrated the marginal nature of the effectiveness of this type of application to control this insect. When used in an aerial application, Guthion gave fair control of the nut casebearer and was superior to methyl-ethyl Guthion. Sevin was ineffective.

On the other hand, good control was obtained with a combination of DDT and parathion applied with a standard high pressure sprayer.

2. Grape Insects. In Ohio the speed of operation of the fan on an air-blast concentrate sprayer, applying a 4 X concentration of methoxychlor at 1900 RPM (low speed), 2800 RPM (medium speed), or 3700 RPM (high speed), had no significant effect on the level of residues obtained on grape berries or on control of grape pests. In a vineyard with heavy foliage overhanging open, fixed spar, and overhanging hooded boom grape sprayers were equally efficient in applying DDT sprays as measured by determination of deposits and insect control.

#### G. Insect Vectors of Diseases

Spread of many important virus diseases is due to the activity of insects and mites. Knowledge of the insect and mite vectors is necessary as a basis for developing methods for preventing spread of the viruses and for determining their host range, season of spread, and other characteristics.

1. Phony Peach Virus. Transmission tests with Oncometopia nigricans, until recently confused with O. orbona, an important proved vector of the phony peach virus, failed to confirm the one previous positive transmission obtained with this species. However, the incubation period of this virus, 2 to 3 years, is so long that confirmation may yet be obtained from tests now underway.

It has been demonstrated in tests conducted in Georgia with the cooperation of the Plant Pest Control Division and Georgia Department of Entomology that populations of the important natural vectors of the phony peach virus can be reduced to a very low level by spraying mixed wooded areas where the vectors hibernate near peach orchards with DDT in two applications about a month apart in the spring. Thus far it has not been possible to correlate reduction of vector populations by this means with a corresponding reduction in the spread of the virus. In a test at Barney, Ga., now concluded, good control of the primary vector, Homalodisca coagulata was demonstrated but phony incidence was disappointingly high. Lack of roguing may have been responsible for the increase in this particular case. In two similar study areas underway near Fort Valley, Ga., vector populations have been reduced to a very low level and thus far spread of the virus has been very limited; however, observations on disease spread in the test orchards over the next two or three years will be necessary to establish the value of this type of control program.

The systemic insecticide Di-syston was very effective in killing phony peach vectors when applied to the soil about young trees at 3 or more grams per tree but damaged the trees severely. Use of Di-syston at 1 gram per tree killed the vectors too slowly to prevent them from effecting virus transmission and also injured the trees regardless of the manner of application. Compound NIA 9205 was less phytotoxic than Di-syston but was



not effective in killing the vectors.

2. Peach Mosaic Virus. For the third consecutive year treatments were applied to all peach plantings, 1643 trees at the outset, in an isolated district in San Bernardino County, California, to determine if peach mosaic virus spread by the eriophyid mite vector, Eriophyes insidiosus, can be prevented. In 1961 and 1962 the treatment was a single spray application at petal fall of 25% diazinon wettable powder at 2 pounds per 100 gallons of spray. In 1963, 1 pound of 50% diazinon wettable powder per 100 gallons was used. It was expected that the spring assay of new cases of disease in 1963 would begin to show effects from the chemical treatments, if any. Indications are that the sprays have been effective since for the first time marked reductions in the numbers of newly infected trees are being recorded.

3. Latent Stone Fruit Virus Complex (ring spot, sour cherry yellow, etc.) All research relating to insect transmission of the latent virus complex in stone fruit trees was concentrated upon the ring spot virus at Corvallis, Oreg. The work there culminated an extensive search for a vector or vectors of stone fruit ring spot virus during which 130,293 individual insects and mites were manipulated. The experiments included 32 species of aphids, 22 leafhoppers, 1 spittlebug, 2 whiteflies, 1 plant bug, 1 beetle, 2 thrips, 3 eriophyid mites and 2 spider mites. Cases of diseased plants occurred in two instances, once in a test of the aphid, Amphorophora rubitoxica, and once in a test of the leafhopper, Eusecelidius variegatus. Unusual precautions were taken by the workers conducting the studies to insure against accidental contamination of the plants, leading them to advance the following conclusion: these transmissions are believed to represent infrequent mechanical transfer of the virus by insects; thus these insects are not considered to be vectors of the virus in the usual sense.

From other studies in the cooperative Federal-State project in Oregon, and results of research reported from other locations, the hypothesis of pollen transmission is considered at present to be the most promising explanation of field spread of this virus. Emphasis on this project has been shifted to evaluate this possibility before continuing the intensive search for an arthropod vector. Since the stone fruit ringspot virus occurs in host plants which cannot be cross-pollinated, infrequent insect transfers may be the means of overcoming this barrier to transfer of the virus among different kinds of plants. A field plot has been established to evaluate pollen transmission as a means of field spread of stone fruit ringspot virus.

4. Miscellaneous Stone Fruit Virus Diseases. As reported last year, based on 12 positive cases of transmission, a new species of eriophyid mite from the wild cherry, Prunus emarginata, was determined to be a vector of cherry mottle leaf virus, cause of a disease that is important in sweet cherries in Washington and Oregon. Further work has added four additional

cases, and continuing observations of 300 new experiments should reveal additional successful transmissions. This will complete this phase of the study with this virus.

In Oregon the Federal-State cooperative project encountered an unusual advance by determining a vector of a new, economically threatening virus in sweet cherry, a few weeks after the presence of the virus was confirmed. Pathological studies to date have indicated that the virus is unrelated to stone fruit ringspot virus. The virus has been carried from sweet cherry to peach and also to squash, and from the latter host back to cherry. The aphid, Myzus persicae, transmitted the virus in the initial experiments, and the transmission pattern is now under study. This represents the first instance of a true vector of a stone fruit virus proving to be an aphid.

The peach rosette virus disease continued to increase in Georgia. Thus far results of 181 transmission tests initiated in 1962 with a variety of insects associated with diseased peaches and plums and 54 tests initiated in 1963 have been negative.

5. Pear Decline. The question of whether the pear decline disorder is attributable to toxins injected into the trees by the pear psylla, or to infection by a virus has not been resolved. During the year weight on the side of the virus hypothesis was added by State Experiment Station workers in Washington with issuance of a publication; earlier the theory that pear decline is caused by pear psylla feeding, with no virus involved, was developed from separate research by other Washington State workers.

Federal entomological work on the pear decline problem dealt with experiments intended to reveal possibilities of certain insects and mites functioning as vectors of a causal virus, and experiments to reveal the capabilities of the pear psylla to produce decline through injection of toxin. In the studies of possible virus transmission, the pear psylla became a primary subject of study separate from the evaluations of direct effects of its feeding and introducing toxin. In greenhouse vector tests with the pear psylla, 108 separate experiments were initiated, utilizing insects which had fed upon declining pear trees. Ten species of leafhoppers which inhabit pear orchards were similarly used in a series of 106 experiments. Test trees were in their first year of growth. Interesting tree reactions are being recorded in certain series, but these may be temporary and unrelated to true pear decline; insufficient time has elapsed (one year and less) to justify as yet an evaluation of results.

Another approach involves use of larger healthy test pear trees planted in the soil inside screen cages large enough to permit growth for 5 to 6 years, when kept pruned to a 6-foot height. Such trees are approximately the same size as those observed in the field to react typically when entering a decline condition. Five cages were erected, each enclosing 21 trees; one group is maintained free from insects; one group receives pear



psylla from diseased field trees; one group receives pear psylla from field trees in a decline-free area; one group receives pear psylla reared on healthy trees; one group receives buds and grafts from diseased trees. This experiment was initiated in the spring of 1963, and by all precedent should reveal some results after one to two years.

The trees in the 172 vector tests reported last year with a new species of eriophyid mite occurring on pear are being observed. All tree reactions need to be observed for a longer period to permit accurate assay of results.

Surveys for pear psylla infestations and pear decline disorder in California did not reveal any significant extensions of the ranges of either. The San Diego County pear psylla infestation remains the only Southern California record.

#### A. Insect Control Treatments for Commodities Regulated by Plant Quarantine

Deciduous Fruit Insects. Specifications for minimum methyl bromide concentrations were developed at Hoboken, N. J., for use by the Plant Quarantine Division in tarpaulin or van fumigation of Chilean fruit (plums, grapes, apples, etc.). These permit immediate correction for under-dosage or leakage loss. The tolerance of Chilean plums (Santa Rosa variety) was satisfactory at recommended schedules of 4 lb. of methyl bromide for 2 hours at 40-49° F., and 6 lb. for 2 hours caused injury.

Tests in New Jersey indicated that complete control of curculio can be obtained in blueberries with 2 lb. of methyl bromide per 1000 cu. ft. or 1½ lb. in combination with 1/2 lb. of ethylene dibromide. Maggot infestation in apples or blueberries was again controlled with low concentrations of methyl bromide or ethylene dibromide. Prepupae apple maggots four or more days old were highly resistant to fumigation, some surviving treatment with methyl bromide at 2 lb. for 4½ hr. near 71° or 5 hr. near 51°, or a combination of 1½ lb. of methyl bromide and ½ lb. of ethylene dibromide for 4 and 5 hr., respectively. These schedules are above the tolerance limits for apples and some other fruit. There was no difference in the resistance of pupae developing in apples or blueberries.

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CROP HARVESTING AND HANDLING OPERATIONS AND EQUIPMENT  
Agricultural Engineering Research Division, ARS

Problem. This area is concerned with the development of equipment and methods for efficiently harvesting and farm handling crops, with emphasis on the preservation of inherent qualities during these processes. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Research on deciduous fruit harvesting equipment at East Lansing, Michigan; Wenatchee, Washington; and Davis, California; is cooperative with the Experiment Stations in those States, and with producers, and machinery manufacturers. Crops under study include: apples, pears, peaches, apricots, plums, grapes, blueberries, cherries, and dates. The Federal engineering effort devoted to research in this area totals 30.5 professional man-years, of which 5.5 is on deciduous fruit and tree nuts.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Harvesting is the only step in the growing, handling, and packing of apples that has not been extensively mechanized. It is a serious problem because of high costs, periodical shortages of labor, and the difficulty of harvesting the entire crop at proper maturity. A total of 4,528 pounds of Ontario apples were harvested with a tree shaker, stored at 32° F. for four months, and processed into frozen slices. This fruit was compared to 5,342 pounds of hand-picked apples from the same orchard and handled in the same way. Machine picking caused some bruising and resulted in an increased processing cost of \$7.05 per ton. However, the savings in the orchard amounted to \$7.50 per ton. It is hoped that further research in catching equipment should result in a reduction of the increased processing cost from \$7.05 to under \$1.00 per ton. Research again showed that pruning trees with the cutter bar hedger is feasible. Present cutter bars are not designed for cutting wood up to 2-3 inches in diameter. Motion and strain studies of the mower bar were made and useful design criteria is being obtained. Research continued on the pick-and-drop method of harvesting apples. A rotating table fruit receiver was developed which increased the pickers output by about eight percent over previous experimental equipment. A conveyor-type fruit receiver with adjustable height and elbow-type swing was developed for use in picking dwarf trees. It increased pickers output by 11 percent.

Cultivated blueberries are grown commercially in the Mid-Atlantic States, Great Lakes area, and the Pacific Northwest. Although this project has developed equipment and methods which greatly reduce the cost of harvest and packing blueberries, costs are still rather high and can be reduced further. Follow up studies of the mechanical picking unit developed on this project showed that 35 percent of the Michigan blueberry crop and about 20 percent of the New Jersey crop were harvested mechanically at less than half the cost of hand picking (3 1/2 cents per pound vs. 8 cents per pound). Considerable work was done on the experimental continuous blueberry harvester. A design was developed that proved effective; and if a commercial version can be constructed, it should reduce the cost of harvesting to under one cent per pound. The machine which straddles the blueberry bush has a set of free rotating spindles on each side. Each set of 80 spindles, 27 inches long is vibrated at a frequency of 3,000 c.p.m. (cycles per minute) through a 5/16-inch stroke. The automatic pint cup feed mechanism which was developed improved the performance of the experimental cellophaning unit and an equipment manufacturer is putting a packing machine on the market for next season which incorporates the principles of the cup feed and cellophaning unit.

Although research on prunes has led to the adoption of mechanical harvesting in the Sacramento Valley, prunes are still harvested by hand in the Santa Clara Valley where prunes fall to the ground as they mature over a month period. A commercially available frost protector blower (six foot propellor--air velocities of over 100 m.p.h.) was modified by installing nine-inch louvers that could either be rotated or oscillated in front of the air stream. Two different travel speeds (2 1/2 m.p.h. and 1 1/4 m.p.h.) were used with rates of oscillation and rotation of 60 per minute in harvesting four plots of 60 trees. The prunes were harvested every four or seven days. Results showed that this method was very selective in removing only the ripe fruit. However, the total removal was lower than desirable especially on the last harvest. The results were promising and further research will be conducted possibly with supplemental shaking.

Bark damage can be a serious problem when tree shakers are used to harvest or thin fruit. Late in the 1961 harvest Ceratocystis Canker was discovered in some prune trees at the point at which the shaker was attached to the tree. A testing unit was developed to apply radial and tangential forces to the limb. The actual force applied could be measured by the pressure in hydraulic cylinders of the unit. Evaluation of the injury to the tree (bark and cambium) was done by visual observations and also by inoculation of the test area with a solution containing the fungus spores. Results of the visual inspection indicate that on young prune trees bark discoloration occurs at approximately 300 p.s.i.; cambium discoloration occurs at 600 p.s.i. radial stress, and failure in tangential shear occurs at approximately 150 p.s.i. On older trees, discoloration occurs at somewhat greater stresses. For the inoculation tests, infestation by Ceratocystis occurred on older trees at a radial stress of approximately 1,000 p.s.i. and a tangential stress of 200 p.s.i. These critical stresses were about three-fourths as much on younger trees. Therefore,



a clamp designed to not exceed 500 p.s.i. radial and 100 p.s.i. tangential stress would leave a margin of safety of approximately 2.0. To do this the contact area must be sufficiently large to distribute the clamping and shaking forces and tangential forces must be minimized. To accomplish the above objectives, a clamp with short continuous reinforced belts placed around rollers was designed and tested. The belts move on the rollers for alignment with the limb and being flexible, conform to limb shape. Field tests with this unit showed no visible bark injury and an inoculation test of limbs shaken showed no evidence of infestation. Another longer range project was initiated where threaded bolts were permanently installed in the trunks of various aged trees. Results thus far show the method might be feasible. Whether or not it is practical depends on economics.

From one-third to one-half the gross returns of both sweet and sour cherries are paid to workers who harvest the crop by hand. In fact, last year, growers received 4.7 cents per pound for sour cherries and paid 3 cents per pound to the hand pickers. Not only is the cost of hand-picking becoming prohibitive, but workers are becoming increasingly hard to recruit. The purpose of this research is to reduce harvesting costs and labor requirements through mechanization. Mechanical harvesting equipment for cherries which was developed on this project and which was used commercially last year to harvest several million pounds of fruit, was given further study. Accurate records were kept on the sorting and processing of 55 tons of machine-harvested cherries and 33 tons of hand-picked cherries. Results showed that Grade A packs were made when machine-picked fruit was processed. Harvesting equipment was improved to the point at which the units ran through the season without major breakdowns. Some equipment ran day and night for 20-24 hours a day. A study of terminal velocities of various fruits including cherries was completed and a report prepared for publication. Results show the terminal velocity of tart cherries is 510 inches per second, of grapes (Delaware) 600 inches per second, and of blueberries 375 inches per second. The results of this work are useful in mechanical injury, fruit separation, and cleaning studies. Over 120 different types of cushioning materials (foam, plastic, foam rubber, etc.) were subjected to impacts and rebound velocities and impact forces were determined. The data is now being run through a computer and analyzed. Sweet cherries were harvested into and handled in bulk boxes at depths of 10, 12, 14, and 16 inches, transported 110 miles and brined. Results showed that sweet cherries can be handled in bulk boxes at depths of 14 inches with savings in time, labor, and money without loss in quality.

About 225,000 tons of Concord grapes are produced each year in the six States of New York, Michigan, Washington, Pennsylvania, Arkansas, and Ohio. Conventional harvesting and handling methods are expensive and cause considerable damage to the raw product. A grape box pick-up mechanism was constructed, mounted on a tractor and field tested. Using the machine saves time and money. A report of this study has been prepared for publication. Some trials on machine harvesting of Muscadine grapes indicate that shaker equipment can be developed for this crop when the acreage warrants it.

Harvesting Cling-Stone Peaches and Apricots. Hand labor for harvesting tender flesh fruits has been difficult to recruit. Previous research showed that mechanical shakers were feasible, but that bruising would be a problem. This season approximately 10 acres of cling-stone peaches were mechanically harvested by two different manufacturer's equipment. One operation used a trunk shaker and the other used two limb shakers. Harvesting rate was approximately 32 trees per hour; 216 boxes per hour or about 70 boxes per man-hour. The results showed that the shakers were non-selective as to fruit maturity and that bruising was five to ten percent more than hand harvesters. Injury occurring in the catching operation was studied and data obtained on energy relationships for fruit bruising and the ability of certain materials to absorb a higher percentage of the fruit kinetic energy. Results indicate that properly designed decelerator strips were the most effective for reducing injury. However, in areas where these strips cannot be used, a padding material which absorbs energy is preferred over one which momentarily stores energy and then releases it, accelerating the fruit upward into other falling fruit. Of the materials tests, an expanded polyethylene--was found to be the most suitable.

Mechanical Thinning of Peaches. Hand thinning of peaches and apples is expensive and labor consuming. Chemical thinning of peaches and early variety apples is considered impractical by most growers because of the inconsistency of the results. Tree shakers are now available for harvesting some fruit, and they can be used for thinning. A comparison was made among hand, machine, and machine followed by hand, methods of thinning. Technical aspects of thinning such as size distribution of the fruit removed, distribution of persisting fruits, etc. were determined. A comprehensive report on the mechanical thinning of peaches was prepared and published.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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## II NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

### UTILIZATION RESEARCH AND DEVELOPMENT

Western Utilization Research and Development Div., ARS

Problem. Fruits and nuts are valued for their unique flavor, color, and natural vitamin content. In the period of abundance at harvest time, markets are glutted and growers often do not get an adequate return. Crops are perishable, and processing to preserve their unique qualities is difficult. No processed fruit retains completely the fresh values, although many highly acceptable products exist and about half of the fruits and nuts marketed in the United States are processed. Processing makes these commodities available to consumers the year around, and has opened new markets for producers. The proportion of processed commodities is steadily increasing but is dependent upon a continuing flow of new knowledge. Processing to preserve color, flavor, and texture presents many problems generally, and each new product requires the application of much scientific and technological skill.

The freezing process for preserving certain fruits keeps the products excellent at near fresh fruit condition. In spite of the gains in quality realized in freezing, many unsolved problems remain. The enzymatic browning of frozen peaches and the sloppy texture of frozen strawberries on thawing are two good examples.

Frozen fruits require expensive low-temperature storage and transportation facilities. The expense is greatly reduced by removing a portion of the water from the products. Orange and other fruit juice concentrates are well established in U.S. markets, and dehydrofrozen apple slices (rapid drying to 50% bulk weight and then freezing) are just becoming well established. Many other fruits and fruit juices should be amenable to concentration. Products of this type, however, are not so well adapted for export as those which do not require refrigeration.

The maximum weight reduction can be achieved through dehydration. The drying of fruit juices has been successfully accomplished by the vacuum puff drying and foam-mat drying processes. The latter is under intensive study, because it can be carried out at atmospheric pressure and consequently offers economy in processing. This process must be worked out in detail for many, as yet untried, fruit purees and juices and on pilot-plant scale for those products that show promise. Flavor recovery and the incorporation of recovered flavor in solid carriers for addition to the dried products require technological and basic chemical study. Essence recovery techniques developed for fruit juice concentrates are not completely satisfactory for this purpose.

Dried and canned fruits are now widely used in the U.S. and abroad. The popularity of dried fruits overseas and in this country would grow if stable, higher moisture dried fruits were available and if lower levels of sulfur

dioxide could be used without loss of quality. Control of mold spoilage in high-moisture dried fruit requires effective antimycotic agents.

Container costs for canned fruits limit the shipment of these products overseas. A solution of the container problem may be found in the use of lightweight fiber, foil, or plastic containers and aseptic filling procedures.

Fruit growers need new varieties of tree fruits and berries suited to processing and resistant to diseases endemic to each region of production. Utilization research is required in cooperation with farm research to assure growers of a market for fruit in the processing industry.

#### USDA PROGRAM

In the Western Utilization Research and Development Division, a broad program of basic and applied research on deciduous fruits and tree nuts is conducted at the Division headquarters at Albany, California; in field stations at Pasadena, California, Prosser and Puyallup, Washington; by contract in Honolulu, Hawaii; by grant at Cambridge, Massachusetts; and by grant funds under P.L. 480 in Israel. Fundamental research is conducted on fruit constituents that are involved in the flavor, color, and texture of fruit products, and includes development of laboratory tools to isolate and characterize individual components, investigation of such components as they occur naturally and as they are altered by operations involved in preservation, and the relationships between the components and the product values being preserved. Applied research is conducted to develop new and improved processes and products that will increase utilization of fruits and tree nuts, including the development of high quality concentrated and dehydrated products and more stable shelled tree nuts and the selection of improved processing varieties. Pioneering research on plant enzymes is also conducted.

The Federal program of research in this area totals 47.2 professional man-years, including two scientists whose salaries are provided by two cooperators (Dried Fruit Industry Research Advisory Committee, whose membership represents the California Raisin Advisory Board, the Dried Fig Advisory Board, the California Prune Advisory Board, and the Dried Fruit Association of California; and Diamond Walnut Growers, Inc. - one each), under Memoranda of Understanding; one contract providing research at the rate of approximately 0.5 professional man-years per year, and one grant providing research at the rate of approximately 0.5 professional man-years per year. Of this number, 24.5 are assigned to investigations on chemical composition and physical properties; and 22.7 on new and improved food products and processing technology. In addition, the Division sponsors basic research on fruit by means of a P.L. 480 grant.



## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Fruit Pigments. Color preservation of many processed fruits involves the chemistry of the anthocyanin pigments which characteristically are red, purple, and blue. Investigations of natural and synthetic anthocyanidins continue to reveal new information concerning the structural relationships of individual compounds to color and the chemical changes that may be induced. An oxidative rearrangement of flavylum salts to 2-aryl-substituted benzofuran derivatives is of major scientific importance. It suggests the pathway both for color losses from fruit products and the natural occurrence of benzofurans, some of which are known to have biological activity. Because yields of benzofurans are very efficient (up to 50%) with starting materials that are easily obtained, this pathway for the synthesis of coumestrol and closely related compounds appears quite promising. Coumestrol, an important benzofuran, is a natural compound in alfalfa and legume forages which exhibits estrogenic activity. This newly discovered synthesis will become the basic approach to building a broad spectrum of estrogenic compounds to study their effects on animal metabolism in meat production.

Study of anthocyanins led to the elucidation of the role of sulfite in the bleaching of fruit products. Contrary to published views that decoloration resulted from the formation of a chalcone bisulfite addition compound, it has now been shown that chalcones derived from anthocyanins do not react with bisulfite. The decoloration is from a reaction of the anthocyanin to form a colorless sulfonic acid derivative. This explains the reversible nature of sulfite decolorizing. Synthetic flavylum compounds have been developed in a range of colors that offer promise of providing safe permanent color to improve processed fruits. Basic knowledge is being sought to block the chemical changes in anthocyanin pigments in fruit products so as to stabilize their color and thereby improve their quality.

2. Enzymatic Browning of Fruit. Basic research on enzymatic browning of fruit has led to a procedure whereby cut apple surfaces or peeled apples can be prevented from turning brown by surface adjustment of the acidity. A methyl-transferring enzyme with action similar to an enzyme from animal sources was postulated on the basis of the browning control of apples. Such an enzyme has now been found in two plant tissues. Apple cambium tissue and pampas grass shoots were two sources of the enzyme preparation, which has been characterized as a 3-O-methyltransferase. It has a high pH optimum and will permanently prevent the browning of natural catechol derivatives of fruit.

Related studies have been initiated under P.L. 480 at the Hebrew University in Jerusalem, Israel. Enzymes of several deciduous fruits are being investigated and identified by their substrate specificity and other properties.

Extraction methods and localization of phenolase enzymes in apples have been investigated and preliminary experiments made to follow changes in phenolase activity during the ripening of apples.

3. Chemical Origin of Plant Structural Tissue. Enzymatic pathways whereby polysaccharides and cellulose are formed and degraded in fruit are under investigation. The demonstration that inositol is a precursor of pectic material in the strawberry was reported. The continuing investigation reveals that biosynthesis of cell wall polysaccharides can stem from conversion of either D-glucose or myo-inositol into anhydropentose polymers. The pentose units derive from the 1 through 5 carbons of D-glucose and 2 through 6 carbons of myo-inositol. Preliminary information points to D-glucuronic acid as an intermediate in either case. A research grant at Harvard has recently been initiated to permit Dr. Porter to extend investigations in this area.

The chemistry of plant cell walls is under investigation because of the obvious importance of cell walls to such characteristics as texture, turgor, and cell elongation. In order to obtain uniform and reproducible cells, at least in the beginning of this work, in vitro tissue culture of tobacco cells was employed. The walls of these cells were found to contain a protein which was resistant to the usual protein extractants. It is also unique in the amount of the amino acids, proline and hydroxyproline. Characterization of this protein and its role in cell wall structure and properties will continue.

4. Fruit Flavor Components. Gas-liquid chromatography has rapidly advanced the chemistry of volatile components in a few years. Dual columns with dual-flame ionization detectors and programmed temperature control achieve remarkable sensitivity. The combination of gas-liquid chromatography with time-of-flight mass spectrometer separates and identifies substances in fractions of a part per million including materials whose separate existences are transitory. For the first time a class of flavor compounds called acetals have been detected in fruit volatiles. Some of the acetals have significant aromas and may contribute important flavor notes to fruits and fruit products.

Refinements in separation and detection of volatile components do not eliminate need for large-scale extraction so as to recover workable amounts of substances that exist in parts per million concentration range of the original fruit. Identifications of some classes of flavor constituents continue to defy existing gas-liquid chromatography and other ultramicro methods. A solvent extraction facility is under construction and nearing completion at Albany, California, that will allow for extraction with necessary low flash-point solvents on a sufficiently large scale to make possible identifications not heretofore possible. The components of deciduous fruits, berries, oranges, and citrus juices will soon be studied on the same scale as investigations on commercially prepared cold pressed orange



oil and other materials which have been obtained in large quantity from commercial installations. Extractions will be obtained in these new facilities with much more complete knowledge of raw material than was ever possible from commercial samples.

Subjective evaluations of flavor are being made on purified organic compounds from food volatiles and believed to be related to product flavor. A trained taste panel determines individual odor thresholds of aqueous solutions of these substances. This is one phase of a systematic approach to provide necessary correlations between the chemistry of volatile compounds and the flavor of foods. In order to study the effect of mixed systems, several compounds have been assembled in sub-threshold concentrations and evaluated together. From preliminary studies it appears that there is an additive relationship between chemical components and olfactory response. Thus, the aroma threshold of a ten-component mixture was identified by a test panel when each of the components existed at one-tenth of its individual threshold concentration. This finding is of great importance and an early step toward interpretation in terms of flavor of the complicated chromatograms obtained in our advanced chemical studies.

5. The Chemistry of Sulfur Dioxide in Dried Fruit. The color and nutrient qualities of several dried fruits are preserved by the addition of sulfur dioxide. In storage, as the sulfur dioxide disappears the fruit turns brown and nutritive qualities are lost. Chemical studies revealed that the disappearance of sulfur dioxide was caused by an oxidation of the compound to sulfate. In order to control this reaction the removal of oxygen from the package was indicated and an oxygen scavenger was devised based on the same oxidation that takes place in the sulfur dioxide conversion to sulfate. A reaction mixture of sodium bisulfite, activated carbon, ferric chloride, and hydrogen peroxide solution, was found to remove 97.5% of the oxygen from 280 milliliters of air in 24 hours. The reaction rate can be altered by varying the ratio between weight of the mixture and the air volume. Composition of the reaction mixture can be adjusted for the production of atmospheres at specific oxygen and carbon dioxide contents, such as are used in the storage of some fresh fruits and vegetables. Application of this new basic knowledge to the improvement of dried fruit products in laboratory experiments, is described in paragraph B-2 below.

6. Pharmacology of Dried Fruit Preservatives. Pharmacological studies, which have since 1960 been partially supported by the Dried Fruit Research Advisory Committee who provided the salary for a scientist hired to conduct the studies, have been concluded. Studies on methyl formate were initiated to obtain toxicity data to assure the safety of this compound. Work on methyl formate was discontinued when this compound was given FDA clearance. Toxicological studies on ethylene and propylene oxide and their derivatives were initiated. In view of the approval for use of propylene oxide on prunes and glacé fruits, work on this substance was not continued. Long-term feeding tests of diethylene glycol, the product of ethylene oxide and water, with laboratory animals were completed. These tests demonstrated

that diethylene glycol added to the diet increased urinary oxalate excretions only at feeding levels that were much higher than ever encountered in application of ethylene oxide to dried fruit. Bladder stones of oxalate were caused in rats, although bladder stones were not observed when diethylene glycol was fed at reasonable levels. Subacute toxicity studies for ethylene glycol in rat diets containing high-moisture dried fruit, indicated that the dried fruit (presumably because of its magnesium content) protected dogs and rats against oxalate bladder stones. Data obtained from this and from two-year feeding tests of diethylene glycol have been given to the Dried Fruit Association for transmittal to the Food and Drug Administration to support a petition for the use of ethylene oxide. In the final report of this research, evidence was presented supporting the conclusion that the commercial use of ethylene oxide as a sterilizing agent for dried fruits in the amount used and under conditions of use does not present a health hazard traceable to ethylene or diethylene glycols. Work is continuing to find a successful method for determining glycol residues in treated products. Such a method is required for clearance of ethylene oxide for use. Natural substances in dried fruit interfere with the determination of diethylene glycol. An effort is being made to avoid such complications and devise a suitable analytical method.

7. Microbial Flora in Fruits and Vegetables. Fundamental studies on the microbial flora within tissues of healthy fruits and vegetables have been concluded in Israel, where they were supported by a Public Law 480 research grant to the Agricultural Research Station of the Ministry of Agriculture at Rehovot. This study demonstrated the presence of certain non-pathogenic bacteria in normal healthy fruit and vegetable tissue. It was demonstrated that only certain types of bacteria are found within the tissue, that many types of organisms found on the surface are not found inside unless the fruit has been damaged, and that the flora found in fresh fruit remain harmless and have limited growth in the intact plant. The organisms do multiply during certain processing operations such as brining, where bacterial growth is necessary to the fermentation involved in preservation. In such cases conditions must be arranged so that the fermenting bacteria will overcome those present within the fruit and vegetables, otherwise an undesirable bacterial growth may bloat or putrefy the brined product.

8. Ethylene Metabolism in Fruit. The enzymes involved in the metabolic fate of ethylene in fruit under conditions wherein ethylene hastens the post-harvest maturation (i.e. accelerates the onset of the climacteric) <sup>3</sup> are under investigation, using ethylene labeled both with C<sup>14</sup> and with H<sup>3</sup>. By measurement of radioactive compounds, it was shown that ethylene gives rise to a large number of volatile metabolites in the avocado. Approximately 12% of the total incorporated radioactivity of metabolized ethylene-H<sup>3</sup> was found in the methyl group of volatile toluene produced; and 5%, in the benzenoid portion of toluene. In addition, 1% of the metabolized ethylene was found in benzene. It was also demonstrated that 9% and 0.5% of the total incorporated radioactivity of metabolized ethylene-C<sup>14</sup> were found in benzene and toluene, respectively. No one had foreseen



that ethylene would be metabolized to those hydrocarbons, or that such hydrocarbons could be found in mature, green avocados. Both discoveries contribute to our understanding of maturation. The isolation and identification of other volatile and non-volatile metabolites are continuing in order to obtain additional information about the enzymes involved in the maturation of fruit with the ultimate goal of controlling maturation prior to processing.

#### B. New and Improved Food Products and Processing Technology

1. Foam-mat Drying. Laboratory and pilot plant investigations continue on the application of the foam-mat drying process invented by Department engineers at Albany, California. Cooperative research with the Southern Utilization Research Division is being conducted on the foam-mat drying of orange and other citrus products at Winter Haven, Florida. Informal cooperation continues with industry representatives who are interested in commercial application of foam-mat drying. Three commercial-scale configurations of the foam-mat drying concept now exist. Two of these have been used for commercial-scale research. One drier has produced commercial lots of foam-mat dried tomato, pure lemon juice, and lime concentrate. Research has been conducted to further reduce the moisture content of already foam-mat dried powders to eliminate the necessity for in-package desiccants for extremely hygroscopic materials. Rotating vacuum drying equipment, using lime as a moisture acceptor and an electrically heated outer cylinder, has been designed. Orange powder can be reduced from  $3\frac{1}{2}$  to 1% moisture by tumbling  $2\frac{1}{2}$  to 3 hours at  $130^{\circ}$  F. A method has been developed to reduce the bulk and improve apparent color of foam-mat dried powders. The powders are run between hot rolls to increase their density and provide for more efficient packaging. Variations in rolling have been developed based on the sensitivity of the products to temperature and the requirements of density specifications. For example, foam-mat dried orange powder is rolled at temperatures between  $130$  and  $180^{\circ}$  F., while tomato powder can be rolled at temperatures as high as  $205^{\circ}$ . Orange solids have been prepared with a density of 0.8 grams per cubic centimeter providing more solid material in a container than is present in a 60% frozen concentrate.

Important flavoring components are frequently lost in the juicing, concentrating, and drying operations required to produce foam-mat dried or any other dehydrated fruit products. Methods are under investigation for adding back important flavor components in a stable form. The locking-in of orange oil with various types of sugars as carriers has been used for some time for citrus powders and formulated citrus beverage powders. Recent research has provided locked-in orange oil at higher concentrations than previously available--up to 10%. The new equipment reduces the time the oil is in contact with melted sugars at a high temperature which might damage the oil. Work will be continued to improve the quality of natural flavors to be added back to foam-mat dried fruit products.

2. Dried Fruit Products. Research on new and improved dried fruit products is continuing partly supported by the Dried Fruit Industry Research Advisory Committee, which provides the salary of a scientist assigned to this work. A process for making a non-setting raisin paste was developed. Raisin paste can be used in many bakery formulations. Heretofore it has set into a hard lump, so that bakers have had to prepare it just before use. A heat treatment was devised that softens raisin paste permanently. Department results were made available to the interested members of industry and successful pilot operations have been conducted. Factory-scale production of non-setting raisin paste is anticipated.

Stability of some types of dried fruit is dependent upon the protective action of sulfur dioxide. However, the preservative is not stable and as its concentration diminishes during processing and storage, so also does its protective action. Much greater conversion of sulfur dioxide occurs during sun drying than during controlled dehydration. Methods have been developed to maintain the level of sodium bisulfite. Low temperature storage and removal of oxygen from the package are two methods of improving sulfur dioxide retention, thereby stabilizing dried fruit quality. An oxygen scavenger system was devised that was highly effective in removing free oxygen from package headspace.

Metal sequestering agents have also been found to improve color stability of dried fruits by an inhibition of oxidation. The improved color stability in this case can be attributed to complexing of metals which would otherwise combine with natural polyphenols to form dark compounds.

Illumination of transparent packages had different effects for different dried fruits. Light shortened the storage life of apples markedly. Apricots were not visibly affected by illumination but lost about 20% more beta-carotene than controls stored in the dark. Dried peaches were essentially unaffected by illumination. The higher deterioration rate of illuminated dried apples implied a more rapid disappearance of sulfur dioxide.

3. Processing Quality of Northwest Soft Fruit and Berry Varieties. So large a proportion of red raspberries, strawberries, and cultivated blueberries produced in the Pacific Northwest are processed that new varieties must adapt to processing to succeed. Processing quality of varieties of soft fruit and berries under investigation by the Washington Experiment Station are being evaluated in cooperative research. During the past year, five varieties and 59 hybrid selections of strawberries were considered. Five established varieties and 11 new selections of raspberries, 20 varieties of blueberries, and 6 of blackberries were evaluated for processing quality. Processing quality, disease resistance, other yield factors, and harvest date, are combined with other horticultural characteristics to determine which varieties should be released for commercial use.

4. Improved Fruit Juices and Fruit Juice Processes. With expanding apple production in the Pacific Northwest, increasing consideration has been



given to the commercial concentration of apple juice. Research is under way on the influence of the degree of concentration on the gelling tendencies of the product. At 48% solids, gel formation was not observed; at 58%, gels occasionally formed; and at 65%, products frequently were found that formed gels. Studies of chemical and structural change in apple components are being conducted in order to overcome this limitation.

Commercial sales of clear red prune juice, based on product developments of the Department's Western Utilization Research Division, have been promising. Storage studies of this product revealed a color instability at high storage temperatures. The product and the puree from which it is made have been found to be very stable frozen. While the product would have a limited shelf life at 50° to 70° F., it is possible to freeze the juice or puree at harvest time and reprocess it any time later for distribution. Savings from the reduced inventory of individual packages (generally glass for this product) and from economic use of equipment in times of normal plant inactivity might compensate for the cost of freezing. This suggested procedure would be especially valuable if processing facilities are crowded at the harvest, which is generally the case in fruit canneries.

5. "Dry-Blanch-Dry" Fruit Process. Conventional sun-drying of fruits occasionally leads to product losses because of rain and high humidity or contamination during field exposure. The "Dry-Blanch-Dry" process for fruits was reported earlier. In contrast to other dehydration this new process imparts desirable translucence previously obtained only by sun-drying. Processing research has continued and conditions established for producing high-quality "Dry-Blanch-Dry" apricots, peaches, pears, raisins, and apples. The process made possible the drying of high-quality apple slices with lower sulfur dioxide content. Light, attractive golden raisins were prepared by the new process without sulfuring.

Exploratory studies on new approaches to dehydration of fruit pieces have been recently initiated.

6. Softening of Brined Cherries. Serious outbreaks of brined cherry softening have plagued the Northwest cherry industry from time to time in the past several years. Cooperative studies have been conducted with the Oregon and Washington Agricultural Experiment Stations and with interested processors and growers to determine the cause and to develop controls. Although the underlying reasons for softening of brined cherries have not yet been resolved, two treatments have been developed that appear to control the deterioration. Heating the cherries and brine to inactivate enzymes and addition of extra amounts of calcium chloride to the brine both prevent softening without adverse affect on the product texture. Brine disposal in cherry processing plants is a serious economic problem. Re-use of the brine from one year to the next would reduce cost of chemicals and avoid the disposal nuisance. Studies on the re-use of brines are being initiated.

7. Stabilizing Shelled Nuts. More and more shelled nuts are being marketed in transparent packages. These products are very attractive at first but they tend to darken and turn rancid rather quickly in the channels of trade. An investigation of what is involved in deterioration of shelled nuts is supported in part by the Diamond Walnut Growers, Inc., which supplies the salary of one chemist assigned to the Pasadena, California laboratory. Previous work at Pasadena resulted in a process that involved critical control of moisture content, use of antioxidants, and sealing in a package with an adequate moisture barrier and has had extensive commercial use. To provide further technological advances, a study has been undertaken of the components of walnuts and the way they vary as rancidity develops in storage. A large quantity of nuts has been extracted and separated into 43 dry fractions, most of which contain more than one compound. Further evaluation of these components will provide a base line for studies of nuts that have undergone deterioration. Kernels of walnuts from two progressive stages of rancidity have also been extracted. Qualitative and quantitative measurements are being made of changes in components. Preliminary results suggest that free amino acids or related compounds and volatile carbonyl compounds formed during oxidation of unsaturated fatty acids are involved in the rancidity.

Contract research on the stability of shelled Macadamia nuts is being conducted by the Hawaiian Experiment Station in Honolulu. Samples of three varieties of Macadamia nuts have been shelled and roasted and adjusted to three moisture levels. Storage tests are being conducted at different temperatures both in the dark and under standard lighting to determine the effects of processing and packaging on the stability of product. Preliminary chemical analyses and organoleptic evaluations of these samples have been conducted and the stability study will continue.

8. Grape Juice and Grape Products. Processing of Concord grape juice and the effects of agronomic practices on composition and quality of juice are under cooperative investigation in the Prosser, Washington, State Experiment Station. A five-year study of Concord grape concentrate, in which nearly 500 samples were analyzed and evaluated, has been completed. Agronomic and processing history is known for each of these samples and correlations will be run. The effect of storage conditions on the quality of Concord juice concentrate has been investigated. At 0° F. a greater loss of methyl anthranilate, an important flavor constituent, was observed than at 32° F. or 60° F. At 32° F. the concentrate was more stable than at 60° F. Grape concentrate and flavor essence that has been recaptured during concentration operations have different storage characteristics. It may follow that concentrate and volatile essences should be stored separately to be recombined when reprocessed shortly before shipping to market.

Research on viniferous grapes has been initiated in order to seek new products that might enlarge markets for surplus wine grapes. Principal attention has been directed towards Thompson seedless grapes. A concentrate of



Thompson seedless grape juice can be transformed to a bland, clear syrup by removing harsh flavor and dark color with activated carbon. The resulting product is a suitable syrup for fruit canning purposes and could bring an economic return for surplus grape juice concentrate. New methods for low temperature concentration are being investigated in order to preserve more flavor in grape products.

9. Fouling of Heat Transfer Surfaces. In the concentration of fruit juices and tomato products, efficiency lost through fouling of heat transfer surfaces results in serious economic loss. In earlier work, a resistance-impedance thermometer concept was developed to measure accurately surface temperatures and make related heat transfer measurements that indicated that fouling was markedly more rapid when products were being warmed than when they were being boiled, and further indicated that fouling was increased by increasing surface temperature, vapor fraction in evaporator tubes, and product viscosity. A relationship between protein denaturation and fouling has led to the initiation of studies on the effect of proteolytic enzymes on control of evaporator surface fouling. Measurements are being extended to rotating steam coil evaporators as they gain commercial acceptance. Simpler generalizations are being sought, so that information obtained in these studies can be applied to existing evaporator installations and to the design of new evaporators.

10. Canned Concentrated Peach and Apricot Puree. An investigation on the effects of temperature and temperature variations encountered during processing, transportation, and distribution of concentrated peach and apricot purees has been completed under a P.L. 480 grant to the Experiment Station for the Food Preserving Industries in Parma, Italy. The behavior of single strength and concentrated peach and apricot purees was studied during various stages of the concentrating and preserving processes and during storage at five temperatures, all above freezing. Objective methods for evaluating the quality of product were developed. Significant changes in organoleptic properties, amounts of tannin-like substances, vitamin content, and viscosity, caused by processing treatments were measured. It was concluded that the following methods can be used to evaluate qualitative changes in peach and apricot purees: (1) variation in thiamine or pantothenic acid content; (2) variation in reflectance color; (3) increase in volatile acidity; and (4) increase in hydroxymethyl furfural content. Although the changes that occur in peach and apricot purees during manufacture, concentration, and storage do not seriously affect the nutritive value of products, the acceptability of products is lowered during prolonged storage, particularly at higher temperatures. Storage temperatures lower than about 65° F., preferably below about 55° F., are needed to preserve organoleptic, physical, and nutritive properties of peach and apricot purees for long periods. This is particularly true for concentrates, since they are less stable than single strength purees under identical storage conditions.

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OF USDA AND COOPERATIVE RESEARCH

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## UTILIZATION RESEARCH AND DEVELOPMENT

### Eastern Utilization Research and Development Div., ARS

Problem. Lack of knowledge of the nature and quantities of the various chemical constituents and enzyme systems present in fresh fruits, and of the changes these undergo during processing, is a limiting factor in research designed to develop new and improved products and processing techniques. Knowledge is required on the composition and physical structure of fruits and fruit products, with emphasis on substances responsible for color and flavor, vitamins, and other constituents important in determining consumer acceptance and nutritive value of the products. Composition should be studied in relation to variety, stage of maturity, and environmental conditions of growth: and to changes occurring between harvesting and processing, during processing, and in storage and distribution. Recently-developed equipment and techniques have made it possible to isolate, separate, and identify constituents that could not have been handled previously. As basic information is developed, new processing techniques will be applied in the improvement of fruit products and in more efficient utilization of by-products from fruit processing.

### USDA PROGRAM

The Department has a continuing long-term program involving chemists, biochemists, and chemical engineers engaged in both basic and applied research related to extending the use of fruits in the food processing industries. In the EU program, apple products research, and investigations on the chemistry and cell structure of cherries are conducted at Wyndmoor, Pa. Development of rapidly-reconstitutable dehydrated fruit pieces is also underway at Wyndmoor. Contract research on peaches is in progress at Rutgers University, New Brunswick, and on apple texture at the Maryland Agricultural Experiment Station, College Park. The Federal (EU) scientific effort devoted to research in this area totals 9.2 professional man-years. Of this total, research on chemical composition and physical properties constitutes 4.5 p.m.y., including 0.4 p.m.y. of contract research on apple texture at the Maryland Station.

Research on new and improved food products amounts to 2.2 p.m.y. Research on new and improved processing technology amounts to 2.5 p.m.y., including 0.4 p.m.y. of contract research on peach processing at Rutgers.

### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

#### A. Chemical Composition and Physical Properties

1. Chemistry and cell structure of cherries for processing. Replacement of much of the hand-picking of red tart cherries by mechanical harvesting seems to be a certainty in the future. Large-scale trials were held in Michigan in the summer of 1962 in which mechanically harvested and hand-picked cherries were compared as to quality of the product for processing. While bruising encountered during mechanical harvesting of the cherries was more extensive than

encountered in hand-picking, it was not excessive. Machine-harvested cherries were found to be of acceptable quality for processing. Laboratory tests show that cherries will tolerate the unavoidable minimum bruising in mechanical harvesting, but rough handling in the steps beyond this point leads to a processed product substandard in quality and yield. Bruising must be kept at a minimum to reduce incidence of scald; in addition, the water used in the storage and hauling tanks should be no warmer than about 60° F. to preserve quality. It was found that aeration of the water is of value in maintaining quality, when it is necessary to hold unbruised cherries overnight above 60°F.

Technical assistance was supplied to the red tart cherry industry in the past year in modifying processing procedures to make the fruit acceptable for export to Western Europe. Over 2000 tons of frozen cherries were shipped to Europe in this first industrial effort to develop an export market.

2. Factors influencing apple texture. Contract research (Maryland Agricultural Experiment Station) on the relationship between the insoluble carbohydrates and the texture of processed apple products was terminated during the period. Firmness of Golden Delicious, York Imperial and Stayman Winesap apples was found to be related to the amounts of alcohol-insoluble solids present at harvest and during storage. While starch was largely responsible for the firmness of immature fruit, this constituent disappeared during ripening and firmness then became dependent on hemicellulose content. Consistency of apple sauce was related to the alcohol-insoluble solids content, particularly the starch fraction.

Contract research (Maryland Agricultural Experiment Station) on the relationship between apple cell wall constituents and the texture of processed products has begun with storage and processing of two commercial varieties. No results are yet available to permit appraisal.

## B. New and Improved Food Products

1. Rapidly-reconstitutible dried fruit pieces. Dehydrated fruit pieces having a porous, rapid-reconstitutible structure are produced by heating the partially dried (25% moisture) pieces above 212° F. in a puffing chamber, then suddenly releasing the pressure, and finally drying in a conventional manner to 2% moisture content. "Explosion-puffing" of blueberries is conducted preferably at 20-25% moisture content; berries "puffed" at above 30% moisture tend to collapse afterward. A rapidly-rehydratable blueberry should be welcomed by the trade, for example, in prepared muffin mixes. Blueberries dehydrated following explosion-puffing rehydrate in 1 to 2 minutes in boiling water and can then be stirred into the mixture of muffin ingredients. This type of blueberry product offers convenient dry pack in the baking mix container, rapid preparation for baking, and flavorful berries in discrete form in the baked muffins.

Apple pieces "explosion-puffed" at 20-30% moisture are rigid, retain their porous structure, and rehydrate on 2 minutes' simmering in water. Commercially-dehydrated apple pieces (20-30% moisture content) fortunately are



suitable for explosion-puffing. This is important in that an organization planning to make this new type of rapid-rehydrating, dried apple piece need not install a line for preparing material to be exploded in the puffing guns. Cost studies indicate that the new type of dehydrated fruit and vegetable pieces can be produced at only a slight increase above that for the manufacture of conventional dehydrated products.

2. Improved apple cider. Pasteurized cider darkens on storage, with accompanying formation of hydroxymethylfurfural (HMF) and sedimentation. Model systems have been used in which it was shown that  $\text{NaHSO}_3$  addition to acidified fructose solution reduced the formation of color and of HMF at pH 3 to 4. Addition of glycine to fructose solution in the pH range of 2 to 6 increased color formation and HMF. At pH 6, color formation was increased and  $\text{NaHSO}_3$  became less effective as a color stabilizer. Future work will deal with utilization of these findings to improve the quality of cider products.

3. Lye-peeling of apples. It was found that lye-peeling of apples is rapid and effective if the skin is dewaxed by hot ethyl or isopropyl alcohol treatment prior to the lye dip, or if alcohol is added to the lye solution. Lye-peeling of apples to be canned would permit much saving of labor and also provide low peeling loss.

#### C. New and Improved Processing Technology

1. Processing characteristics of eastern peaches. Work on this contract research (New Jersey Agricultural Experiment Station) began in June 1962 and continued through the peach harvest season in New Jersey. Ninety-five new varieties of peaches were investigated to determine processing characteristics. Samples from 53 of these varieties were canned and frozen. Preliminary evaluations of color, texture and chemical composition indicate that several of these new varieties show promise for processing.

### PATENTS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

#### New and Improved Food Products

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UTILIZATION RESEARCH AND DEVELOPMENT  
Southern Utilization Research and Development Div., ARS

Problem. The peach industry in the Southeastern United States is dependent to a large extent on the fresh market. For example, in the South Atlantic States in 1960, 14,870,000 bushels of peaches were produced of which 11,865,000 bushels were sold on the fresh market; slightly over 2,000,000 bushels were processed. A peach processing industry is needed in the Southeastern States to provide a profitable market for more of the edible peaches which do not meet fresh market standards and to rapidly convert a higher proportion of the overall crop to stable forms. Climatic conditions which favor rapid deterioration of fresh peaches both on and off the tree, erratic ripening periods and markets, and short lived peach orchards, are other factors contributing to the need for more extensively integrated fresh market-processing operations. There are technical problems preventing the more rapid development of the peach processing industry in the Southeastern States which must be overcome. Many of the peach varieties grown in the southeast require a modification of processing procedures to make satisfactory standard-type products. Still other varieties will not make standard-type products and new food forms must be found for them. Recent rapid advances in food science and processing technology make it possible through research to develop both new and improved peach products. These are needed to bolster the economics of the South's peach industry, as well as to provide the superior qualities, and greater convenience in food products, which the consumer now demands.

USDA PROGRAM

The Department has product and processing investigations in progress under contract at the Georgia Agricultural Experiment Station, Experiment, Georgia. This contract covers research to develop optimum procedures for the production and preservation of puree and clear juice peach concentrates; to develop optimum procedures for the preparation and the handling under simulated commercial conditions of refrigerated fresh peach slices; to develop optimum procedures for canning Southeastern peaches; and to conduct experiments directed to the development of partially dehydrated pasteurized peach products. Evaluation of different varieties of peaches, and of different processing variables are phases of the investigations. This research involves 1.2 man-years, and is carried out with the support of the Area Redevelopment Authority of the Department of Commerce.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Experiments completed in contract research at Georgia Agricultural Experiment Station on the first season's (1962) packs of puree, clear juice, canned, chilled sections, and partially dehydrated peach products from southeastern grown peaches have indicated the more promising leads in developing products with commercial potential. The research demonstrated



that certain peach varieties are suited for the manufacture of all five type products, while some early varieties may not be suited for use in most, if any, processed products (particularly for the retail trade) because of color, flavor, soft or broken seeds, and the like. Other varieties will require special adaptation of processing procedures to make good products. Limited consumer preference tests indicate good market potential for both peach puree and chilled sections. Excellent drinks were made from the purees of frozen and canned peaches in combination with eggs, milk, ice cream, and other additives. In the canning experiments, nature of pretreatment was found to be an important factor and, in general, peaches which had been hydrocooled gave canned products superior in appearance and texture.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

None

**NUTRITION AND CONSUMER USE RESEARCH**  
**Consumer and Food Economics Research Division, ARS**  
**Human Nutrition Research Division, ARS**

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

**USDA PROGRAM**

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville, Maryland, and in Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 66.3 man-years. It is estimated that approximately 9.5 man-years is concerned with studies related to deciduous fruits and tree nuts.



Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 23.4 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to horticultural crops are considered briefly in this report.

#### A. Nutrient Values of Deciduous Fruits and Tree Nuts

1. Tables of food composition. The 1963 revision of Agricultural Handbook No. 8, "Composition of Foods...Raw, Processed, Prepared" was completed and carried through to the galley proof phase. Special attention has been given to bringing together and summarizing all data available on the deciduous fruits commonly used in this country, and all data available on tree nuts used in the United States. The new edition contains information for deciduous fruits and fruit products subdivided on the basis of factors affecting content of nutrients. For example, data are shown separately for fresh and for stored apples. Other apple products included are canned, dehydrated, dried, frozen, and apple juice. A total of about 90 deciduous fruit items are included. Berries, grapes, and other types of fruit and their products add some 70 items to the table. Tree nuts and their products for which data are included in the new edition total about 25 items.

Data in the popular publication, "Nutritive Value of Foods", Home and Garden Bulletin No. 72, have been revised to agree on a weight basis with nutritive values in Handbook No. 8. The revised edition will provide nutritive values of household measures of 512 commonly used foods. Another popular publication, "Conserving Nutritive Value of Foods", Home and Garden Bulletin No. 90, is in press.

2. Vitamin analyses. Research continued on procedures useful for B-vitamin analyses to permit characterization of B-vitamins in deciduous fruits, tree nuts, and other foods and to determine their overall distribution in the food supply. A procedure has been developed for the quantitative determination of pyridoxine (vitamin B<sub>6</sub>) as pyridoxal cyanohydrin. Studies will be continued to apply this chemical procedure to the assay of vitamin B<sub>6</sub> in food extracts and to verify results by comparisons with those of the microbiological assay.

An improved method for thiamine determination also has been developed. The conditions of the 6-aminothymol colorimetric reaction were changed so that a stable fluorescent compound was produced with thiamine. The

fluorescence made possible measurements at much lower concentrations and appeared to be simpler than the usual thiochrome reaction.

3. Proteins and amino acids. A manuscript was published describing a method developed for assay of alanine using Leuconostoc citrovorum 8081 and providing data for 48 proteins and foods including brazil nuts.

4. Mineral elements. Laboratory analyses for the content and distribution of 10 mineral elements in 29 fresh fruits and 6 dried fruits from different locations are near completion. The mineral element content of several fruits varied from location to location. Data are being summarized for statistical analyses and a technical bulletin will be prepared.

Analyses for total nitrogen and ash are in process on the 29 fresh and 6 dried fruits being analyzed simultaneously for mineral element content.

5. Carbohydrates. Studies were initiated on direct laboratory analyses for the carbohydrate content of foods, usually expressed as a difference value in tabulations of proximate composition. The sugars in 20 fresh fruits, including deciduous fruits and berries, were determined by analyses for total sugars, reducing sugars, sucrose (by difference), and glucose and fructose in the reducing sugars by differential oxidation. The studies are continuing on identification and determination of individual sugars in fruits.

#### B. Properties Related to Quality and Consumer Use of Deciduous Fruits and Tree Nuts

1. Organic acids, carbohydrates, and fruit quality. Research is in progress on the types, amounts, and stability of organic acids and various forms of carbohydrate in fruits before and after freezing. The extent to which these components determine quality, texture, and flavor characteristics of peaches, strawberries, raspberries, and cantaloups is being studied. Physical and chemical determinations include citric, malic and quinic acids, pectins, soluble solids, titratable acidity, pH, sugars (glucose, fructose and sucrose), reflected color and shear force.

The enzymatic preparation, Pectinol 100-D (Rohm and Haas), in the colorimetric carbazole reaction was found to interfere in the determination of pectins. Pectinol 100-D used in the amounts recommended for the determination of protopectin produced an interfering color which caused a 20 percent error in results in fresh peaches. If Pectinol 100-D is used for pectin determination it is recommended that a correction for the interfering color be made. Pectinol R-10 (Rohm and Haas) and Pectinol (K & K Laboratories) produced no interfering color.



2. Preservation. Formulas for pickled peaches, pears and watermelon rind were developed and the effects of processing and storage on product quality were investigated. Processed pickled fruits maintained their quality better during storage than did the unprocessed products. The processed pickled fruits showed little deterioration in quality after storage periods up to 9 months. Criteria used were acid, salt, and pH determinations, color difference meter and shear force readings, and panel evaluations of color, texture, and flavor.

3. Storage of dried fruits. Laboratory studies were completed to relate moisture content and quality of uncooked dried fruits of specified types, grades and sizes, that were stored under different conditions, to the quality and yield of the cooked products. A report presenting the results is being written.

4. Food buying guides for school lunch managers. A revision of PA-270, Food Buying Guide for Type A School Lunches, was completed in cooperation with the Agricultural Marketing Service. New data were added to the 1955 edition and the format was changed to make the guide more useable by school lunch managers participating in the National School Lunch Program.

5. Food buying guides for families. Work has been initiated on a food buying guide for family use.

#### C. Nutrient Functions

Carbohydrates. Basic research using small animals and microorganisms is contributing to an understanding of the influence of type of carbohydrate on lipid and protein metabolism and to our knowledge of factors influencing the physiological response to carbohydrate-containing foods such as deciduous fruits and tree nuts. Protein components in the blood serum of rats, particularly rapidly moving components (PA), varied with diet and with age. PA was present more often and in larger amounts with fasted rats fed a sucrose-containing diet than with rats of comparable age on a starch-containing diet. With either carbohydrate (sucrose or starch), more PA was generally present in the serum of 350 day-old rats than in that of 150 day-old animals. With glucose, PA was present in small amounts in a larger percentage of rats, and no age effect was apparent. The percentage of 150 day-old sucrose-fed rats with serum containing PA was higher in nonfasted than in fasted rats; the reverse was observed with glucose. Lipid material was found in the PA components. The presence and amount of these components may provide an additional means of measuring response to diet and may prove a valuable tool for studying lipid transport.

#### D. Requirements for Nutrients

Preadolescent age group. Cooperation has continued with experiment stations in the Southern Region (S-28 revised) for investigation of metabolic patterns and for assessing requirements for and utilization of selected nutrients by preadolescent children. In 1962, at Blacksburg, Virginia, 12 preadolescent girls were maintained on controlled diets with variation in the amount of protein (entirely from plant sources). Several kinds of tree nuts were used in the controlled diets. Analyses completed for intake and outgo of fat suggest that the amount of fecal fat excreted by the subjects was about twice the amount of fat excreted by subjects on controlled diets in earlier studies, where the protein was mainly from animal sources, although the content of total fat in the diets was comparable.

#### E. Food Consumption and Diet Appraisal

1. Food consumption and dietary levels. A report of the findings of the food consumption survey of beneficiaries of Old Age and Survivors Insurance made in Rochester, New York in the spring of 1957 has been completed. The survey included 283 1- or 2-person households. During the survey week, food brought into the kitchens of these households averaged about the following amounts per person: 4 quarts of whole milk or its equivalent in milk products; 4 pounds of meat, poultry, fish; 1/2 dozen eggs; 10 pounds of vegetables and fruits; 2 pounds of grain products (in terms of flour); 1 pound of sugars and sweets; and 3/4 pound of fats and oils. The total money value of all food per person was \$8.12. Nutrients from this food more than met the National Research Council's recommended allowance for the average person. However, less than half (44 percent) of the households had diets which met in full the recommended amounts for all nine nutrients (good diets). Nearly three-fourths of the households had diets that met two-thirds of the recommendations for all nutrients (good and fair diets). The nutrients which fell below the recommended allowances most often were thiamine and calcium.

The series of food surveys conducted in low-income areas to aid in the study of the effects of food distribution programs on diets of families has been extended to include a survey carried out in Choctaw County, Oklahoma and in Pensacola, Florida. These were conducted cooperatively with the Marketing Economics Division, Economic Research Service as were similar surveys reported previously.

A food consumption survey was carried out in the District of Columbia that will provide information on the diets of households and of individuals. The study was undertaken primarily as a pilot survey in developing procedures for the next Nationwide survey proposed in the Department's long-range program.



The nutrient content of the per capita food supply is calculated and published each year, using data on estimated quantities of foods consumed (retail-weight basis) as developed by the Economic Research Service. This series, with estimates extending back to 1909, is the only source of data on year-to-year changes in the nutrient content of the U. S. per capita food consumption.

2. Food management practices. The results from three small studies based on records kept by the homemaker on the kind, amount, and nutritive value of foods used and discarded in households have been prepared as a journal article. In terms of total calories available for consumption, discarded edible food averaged 7 percent in St. Paul, Minnesota; 8 percent in DeKalb County, Missouri; and 10 percent in Los Angeles, California. A study using "recall questions", instead of records, with a random sample of 300 households in Minneapolis-St. Paul in the winter of 1960 is currently being processed.

A report on household practices in handling and storing commercially frozen foods, based on surveys in two cities has been published. Survey findings indicate that household practices alone would not cause serious quality deterioration of frozen foods.

A new study has been initiated (under contract) of the management practices of urban and farm home freezer owners in Fort Wayne, Indiana, and a nearby rural area. The survey is designed to obtain information on such actual management practices of home freezer owners as the kinds, amounts, sources, prices, and rate of turnover of foods frozen and stored in the home.

3. Development of food budgets and other basic data for food and nutrition programs. The ongoing program of interpretation and application of nutrition research findings to practical problems for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education or nutrition policies has involved the preparation or review of articles and publications, talks, television interviews, and participation in various conferences and committees.

With the publication of the report "Family Food Plans and Food Costs" the technical work on the development of the Department's current low-cost, moderate-cost and liberal food plans was completed. The continuing phases of the work on individual and household food budgets consists in the regular pricing of the food plans for publication in Family Economics Review, and in dissemination of information concerning them through such popular publications as "Family Food Budgeting for Good Meals and Good Nutrition", through filmstrips (Food for the Young Couple), and through correspondence, talks and committees (such as the Advisory Committee to the Bureau of Labor Statistics on their City Workers' Standard Budget).

Progress on the revision of Handbook No. 16, "Planning Food for Institutions" has focused primarily on the food purchasing guide section. Publications in preparation that are designed for the use of teachers, extension workers and other leaders are (1) a semi-popular publication on nutrition in the series Facts for Nutrition Programs; (2) a report on fat and related components in U. S. diets; and (3) a study of the relative economy of foods.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides one channel for disseminating pertinent information and for reporting nutrition education activities. Examples of subjects of current interest covered during the report period are: "Nutrition Aspects of Selected Studies of Cardiovascular Diseases--Implications for Nutrition Education", "Planning Nutrition Programs for Elementary School Teachers", and "Food Guides--A Teaching Tool in Nutrition Education".

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

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## III MARKETING AND ECONOMIC RESEARCH

## MARKET QUALITY

## Market Quality Research Division, AMS

Problem. Deciduous fruits and tree nuts are subject to deterioration after harvest through normal metabolic processes and from decay organisms. In addition these products vary widely at harvest in the characters that determine market acceptance. Additional information is needed with respect to the accurate measurement of market quality and the effects that various handling practices and procedures have on the maintenance of quality. Objective measurements of quality would greatly assist in standardization and grading procedures and the development of instrumentation for this purpose greatly increases the chance for ultimate automatic quality sorting on a commercial basis. Additional information is needed on physical and chemical methods for decay reduction and on product quality as related to mechanical harvesting. Research is needed on storage environment as related to temperature, air movement, humidity, atmosphere modifications and fumigants. Consistently safe and effective transportation of the more perishable fruits can be accomplished only by continued research with transportation equipment and services as affecting ultimate quality of the product in the market. Dried fruits are subject to insect infestation from the time they are being dried in the field until they reach the final consumer. There is need for research to develop more effective measures to prevent this infestation all along the line, as raisins are drying in the field, during storage while they await processing, in the processing plant, and after they are packaged. Research is also needed to develop effective measures for protecting tree nuts against insect infestation during storage and after packaging.

## USDA PROGRAM

The Department has a long-term program of basic and applied research involving horticulturists, plant physiologists, plant pathologists, food technologists and chemists. The research in horticulture includes both measurement of quality and maintenance of quality during the period between harvest and consumption. Locations include the laboratories at Beltsville, Maryland; field laboratories at Wenatchee, Washington; Fresno, California; and Raleigh, North Carolina; and market laboratories in Chicago, Illinois and New York City, and contract work at Corvallis, Oregon with the Oregon State Experiment Station. Research on gamma irradiation of fruits and vegetables is underway at the Chicago and Fresno laboratories with some financial help from the Atomic Energy Commission. Cooperative

agreements and limited contributed funds were in effect with the California Strawberry Advisory Board and the California Tree Fruit Agreement. P.L. 480 supported research is underway in England on the effects of modified atmospheres on the physiological processes of apples; in Finland on fungicide residues on fruits as related to time and rate of spray application; and a project has just been initiated in Italy to study the principal rots of apples and pears.

Also there is a continuing long-term program at Fresno, California, which involves entomologists in applied research on the prevention of insect infestation, damage, and contamination of dried fruits and tree nuts in marketing channels. The research is conducted in cooperation with California State and County agencies and with several industry groups. Basic and developmental studies at Savannah, Georgia, involve entomologists and chemists whose research has cross-commodity application. The entire program is discussed in Area 13. Although much of the work on insecticide evaluation, insecticide residue analysis, and insect-resistant packaging has a direct relation to dried fruits and tree nuts, only a proportional part of that effort has been allocated to Area 3.

Federal effort in this program totals 22.3 man-years divided as follows: objective measurement of quality 3.4; quality maintenance in handling and packaging 2.1; quality maintenance in storage 4.2; quality maintenance during transportation 1.2; postharvest physiology 1.8; postharvest disease control 4.2; prevention of insect infestation 4.3; and program leadership 1.1. Research under P.L. 480 includes a 4-year project in Finland on chemical residues for a total of \$56,637 equivalent; a 5-year project in England on the biological effects of modified atmospheres for apples at \$67,031 equivalent; and a new 3-year project just underway in Italy on apple and pear rots for \$18,357 equivalent.

Work terminated during the period included: packaging and cooling of blueberries (MQ 2-4); effect of varying temperature on quality of fruits (MQ 2-17); strawberry decay control (MQ 2-20); quality of dried fruits (MQ 2-9); quality changes in apples during marketing (MQ 2-38); storage of prepackaged apples (part of MQ 2-63); pectinase activity of juice extracted from decayed cherries for brining (MQ 2-16); and control of Drosophila flies in vineyards and fruit dumps (MQ 1-5).

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Objective measurement of quality

1. Eastern Apples. The Light Transmittance Difference Meter (L-TDM) was again used to determine maturity and quality of apples



in cooperation with the West Virginia Agricultural Experiment Station at Kearneysville.

Richared Delicious apples were harvested at intervals throughout the season. The high incidence of water core in the fruit reduced storage life and somewhat confounded the measurement of internal chlorophyll content, which was used as a measure of maturity and quality. Instrument readings, however, showed a gradual downward trend in chlorophyll content as the season progressed.

Titrateable acidity varied with no significant trend or relationship to the instrument reading. Starch content decreased rapidly at first as the fruit matured on the trees with gradual leveling off late in the season.

An automatic light transmittance fruit sorter (Fruit I. Q. Sorter) was received from the contractor. After some changes in optical design, preliminary tests were satisfactory.

Evaluations of the recently developed mechanical thumb were made during the season. Scale drawings of the device together with detailed specifications were prepared and submitted to interested manufacturers.

Exploratory tests were conducted using the L-TDM instrument in an attempt to detect internal browning in apples which develops in storage. Visibly sound McIntosh, Red Delicious and Stayman Winesap apples were sorted into 5 classes for chlorophyll content (measuring  $\Delta$ O.D. 695-740 m $\mu$ ) at harvest. After 6 months' storage at 30-31°F., the fruit was remeasured, with L-TDM, using wavelengths specific for internal breakdown,  $\Delta$ O.D. 720-820 m $\mu$ . Objectionable internal browning from any cause was detected with 48-57% accuracy while severe internal browning was detected with 60-94% accuracy.

2. Western Apples. Studies at the Wenatchee, Washington laboratory showed that apples of different sizes have different values on the Difference Meter scale for the same degree of water core. Consequently, the effect of size would have to be taken into consideration in the commercial separation of water-cored fruit by light transmittance determinations.

Dry weight of the apple tissue was not necessarily an indication of the amount of water core.

Water core intensity was followed through storage at temperatures of 31°F., 44°F. and 65°F. and relative humidities of 65 and 85 percent. Water core disappeared faster with increase in storage temperature. However, a shorter storage life and reduction in quality of the fruit accompanied the higher storage temperature.

Temperatures for the forty days following the 1962 apple bloom were considerably cooler than normal. Although a longer period from bloom to optimum maturity might be expected under these conditions, observations made on Starking Delicious picked at various periods from bloom indicated no great difference from previous years. When the fruit was examined in May (after 8 months' storage), that harvested at 140 to 150 days from full bloom had the best quality as judged by a panel of tasters. The density of the fruit increased and the chlorophyll content decreased with advanced harvest maturity. Apples with Difference Meter readings of 80 averaged 0.852 specific gravity, whereas those with D.M. readings of 30 averaged 0.895.

3. Red Tart Cherries. Studies were conducted in Pennsylvania with a Light Transmittance Difference Meter (L-TDM) as a means of detecting scald.  $\Delta$ O.D. 730-800 mu was found specific for this disorder.

Evaluation of scald damage with the L-TDM and by visual external and internal ratings of cherries indicated that mechanical harvesting plus water tank hauling can result in cherries either comparable to or somewhat inferior to those handpicked and transported in field boxes or in water tank. The type of mechanical harvester and the care with which it is used appear to be the major factors determining incidence of scald damage and internal breakdown.

Samples of red tart cherries which graded 90-97 usable were found to be variable for anthocyanin pigment development ranging from 48-81 on the L-TDM. Such fruit was graded C and Sub-standard (primarily because of scald) when frozen. When heat processed in cans some cherries from the same lot graded A, but the major portion graded C and Sub-standard (primarily due to scald damage). A wider range of color for frozen than for canned product appeared acceptable for grade A, as long as uniformity was maintained in individual containers. Extremely dark cherries may be downgraded for color in the canned product according to the grade.

#### B. Quality maintenance in handling and packaging

1. Eastern Apples. A study was made at Beltsville of ethylene accumulation within various sealed liners of apples. Ethylene was present within the different types of liners at concentrations of 500 to over 3500 ppm at the end of the storage period.

A rapid technique for positive identification of different kinds of films was developed using light at frequencies between 1.8 and 12.5 microns. Some chemical changes in liner compositions may occur during storage.



Liner permeability studies at 32° F. indicate that temperature relations probably depend on the activation temperatures of the plastics, and may be exponential, but these thermodynamic confirmations continue to be difficult. Equipment for a rapid method of gas transmission measurement at cold temperatures has been made and is being tested.

Pads and small bags containing 1 pound of fresh hydrated lime for absorbing CO<sub>2</sub> were packed within sealed polyethylene-lined corrugated boxes of Delicious, Golden Delicious, Rome, and Jonathan apples. Other boxes were packed without lime to determine the accumulation of CO<sub>2</sub> with and without lime in the liners in 32° F. storage. Previous tests had shown that a 1-lb. bag of lime was sufficient to keep CO<sub>2</sub> at 1% or below in a bushel of apples during 5-6 months' storage at 32°. Kraft paper pads (12x20 inches) containing lime, placed beneath the fruit, were as effective as kraft bags of lime for absorbing CO<sub>2</sub>. The CO<sub>2</sub> averaged 6.1% within the liners without lime and 0.4% with the lime bags or pads. Small polyethylene bags containing 1 lb. of lime and perforated with 5 pinholes maintained an intermediate CO<sub>2</sub> level, averaging 4.1%. Delicious apples were 1 to 2 pounds firmer after storage when CO<sub>2</sub> was kept below 1% than when CO<sub>2</sub> was allowed to accumulate. Rome apples had less internal browning and soggy breakdown when CO<sub>2</sub> was held below 1% in film-lined boxes.

Ten tests conducted on 5 varieties of apples with 50 grams of activated carbon paper and brominated carbon paper packed within corrugated boxes of apples showed no benefits to keeping quality. Four of the tests were with polyethylene-lined boxes, 6 were without film liners.

One apple packer in West Virginia lost some Golden Delicious apples stored in folded-top polyethylene liners within corrugated cartons. This occurred after only 6-8 weeks in storage. Investigation by Beltsville and V.P.I. horticulturists disclosed that CO<sub>2</sub> had accumulated to 6-10% in many boxes, which is higher than ordinarily expected. Oxygen was at a low level of 1-2% in some boxes. Boxes with high CO<sub>2</sub> of 8-10% and O<sub>2</sub> below 3% were most severely injured; usually 50% or more of the fruit in such boxes had severe internal injury. The suffocation injury appeared much like soggy breakdown and the fruit was off flavored. Damaged fruit was much more prevalent in the larger sizes than in smaller sizes. Some fruit was injured even when CO<sub>2</sub> measured only 4-6% in December, but probably CO<sub>2</sub> was higher soon after harvest. At least four recommended procedures were followed by the grower: (1) the fruit was of good maturity for storage, (2) it was precooled before packing in film, (3) it was stored at 31°-32° F., and (4) the liners were 1.5-mil polyethylene. Two factors responsible for the suffocation injury are believed to be unusually high fruit respiration and too tight

a pack. The polyethylene was essentially sealed when an inverted molded-pulp tray was placed on top of the overlapped-film closure before lidding the boxes. The use of perforated liners, or liners which can not be heavily overlapped will be recommended in the future to avoid this injury. Use of hydrated lime inserts probably would have prevented the injury.

Jonathan and Delicious apples from 3 orchards were stored at 32° and 40° F.; half packaged in 4-lb. perforated polyethylene bags with 12 bags per shipping carton; and half, loose in field boxes. Fruit was examined monthly for 5 months. Rate of softening and amount of decay during storage were not appreciably different for apples in consumer bags or loose in boxes. Apples in film bags lost about half as much weight as fruit in boxes. Shriveling, a problem with some lots of Jonathans, was also reduced by storage in film bags.

The storage response of both varieties varied markedly between the 3 orchards, thus any general recommendation is limited. Film-bagged fruit stored for more than 2 months at 32° developed some scald, internal breakdown, and other defects that would necessitate repacking of some bags prior to sale. Use of the scald inhibitor, ethoxyquin, caused a slight browning of polyethylene bags when they were exposed to light for 2 or more days. This work on storage of prepackaged apples is completed.

2. Western Apples. Consumer bags of nine different polyethylene formulations were tested at Wenatchee to determine their propensity for fogging or clouding when used for Delicious and Winesap apples.

The fruit was packed in the bags on December 26, 1962 and, after packing, the bags were placed in apple boxes and put into storage at 31° F. Two months later, on February 27, half of the bags of each lot were removed from cold storage and placed at 70° for observation for fogging. No fogging was visible when the packages were removed from 31°. After approximately a month, marked differences were apparent in the films. Fogging was more severe with Winesaps than with Delicious, but the tendency for the various bags to fog or resist fogging was the same for both varieties.

The bags classed as slightly fogged were not considered objectionable. All the bags had some spots that appeared to be from contact with the apples, but the spots were not typical fogging.

The remaining bags of fruit were removed from 31° storage on June 27, 1963 and examined after the condensation moisture had disappeared. Four of the bag films were clear while the remainder were cloudy or tacky.



3. Peaches. In shipping tests from Georgia and South Carolina to northern markets, less bruising of peaches occurred in 38-pound Du-all crates (a combination wirebound and moistureproof corrugated container) than in the conventional tub baskets. An average of 5.7% of the peaches shipped in Du-alls were bruised in transit as compared to 10.2% of those shipped in baskets.

Bruising was also compared in Du-alls and non-moistureproof, corrugated cartons. Peaches shipped in the cartons were hydrocooled in field boxes prior to packing, while peaches in Du-alls were hydrocooled in the shipping container after packing. Bruising was about the same in both types of containers. Both containers held up well during transit.

In a comparison of bruising in conventional tub baskets and flat-top or (Pallet-Pak) baskets, 9.5% of the peaches in conventional baskets were bruised on arrival in the market and 8.9% in Pallet Paks. The percentage of peaches with cuts was greater in the Pallet-Pak than in the conventional basket.

4. Blueberries. Results with fruit obtained from plants grown in in the greenhouse with 5 levels of N, P, K, Ca and Mg confirmed the previous season's results that nitrogen nutrition affected acidity, soluble solids, size, rate of ripening and keeping quality. These factors were associated with fruit: leaf ratios which indicate that high ratios (i.e. 7 to 8 fruit per leaf) decreased berry size, soluble solids, slowed ripening and increased acidity.

In 8 tests, in North Carolina, half cooling times were reduced from about 90 minutes to 30 minutes by modification of the master shipping container and the use of less expensive slotted pulp cups instead of the standard veneer till. Faster precooling aids in drying and maintaining quality of fruit harvested wet. Commercial harvesting is now delayed when the berries are wet.

5. Pears. Preliminary studies on waxing Anjou pears in a commercial operation at Cashmere, Washington indicate that the process may have some beneficial effects in extending the storage life of the fruit. Waxing caused retention of the green color in some fruits during ripening. Carbon dioxide in the internal atmosphere of the pears was three times as high at removal from cold storage as in the unwaxed pears. After 10 additional days at 70° F. internal CO<sub>2</sub> was almost twice as high as that in the untreated fruit. Further work is needed to establish safe and effective wax compositions and practical application methods. (Exploratory Research)

### C. Quality maintenance in storage

1. Eastern Apples. Sixteen lots of Red Delicious apples were stored at 32° F. for 6 months under different atmosphere of CO<sub>2</sub> and O<sub>2</sub> at Beltsville to observe the response of the fruit to different atmospheres and to record any injuries that developed.

Apples stored in atmospheres of 1 to 3% O<sub>2</sub> and zero CO<sub>2</sub> were practically free from physiological disorders following storage. At zero O<sub>2</sub> and zero CO<sub>2</sub> (100% N<sub>2</sub>) a brown mottled injury similar to soft scald occurred on the skin of 80% of the fruit. Internally, 70% of the fruit from this atmosphere developed browning in the core area. With additions of CO<sub>2</sub> of 5, 10, or 15% in combination with zero O<sub>2</sub>, these same types of injuries occurred. Externally, they were obscured and confounded by the appearance of a severe brown spotting indistinguishable from severe storage scald. Internally, only 19 to 41% of the fruit developed the core browning type of injury. All fruit of the zero O<sub>2</sub> treatments developed a slightly fermented flavor.

With O<sub>2</sub> at 1%, no off-flavors developed and the external soft-scald type of injury as well as core browning were negligible. With increasing amounts of O<sub>2</sub> in the absence of CO<sub>2</sub> mild scald-like symptoms developed externally and flesh breakdown, similar to soggy breakdown developed internally. When CO<sub>2</sub> was increased, along with higher oxygen, the severity of both the scald symptoms and breakdown increased markedly.

2. Western Apples. Commercial "Tectrol" storage in which the desired atmosphere was maintained by a continuous flow of air, adjusted to the desired levels of oxygen and carbon dioxide before it was introduced into the storage room and conventional C.A. storage with 2 to 3 percent oxygen and 1 percent or less carbon dioxide, obtained by respiratory activity were compared with regular air storage for Delicious apples at Wenatchee, Washington.

The first fruit was removed after about 90 days' storage. This represented the minimum period required by Washington State law for C.A. fruit. Storage was terminated May 1, after a total of about 7 months. After both the short and long storage period firmness, soluble solids, and taste-panel rating were similar in the three lots of fruit. There appears to be little advantage of controlled atmosphere storage for Delicious apples in the Northwest. The principal difference observed was in the higher acid content of the C.A. fruit. More total scald and substantially more severe scald developed in the apples stored in the Tectrol room than in the fruit from the other storages. Work on C.A. storage of Northwestern Delicious is completed.

Relative humidity was studied as a factor related to the development of mealy breakdown of California-grown yellow Newtown apples after storage in controlled atmospheres. Apples examined immediately after storage (8 months at 42° F.) showed no breakdown, but after 10 days at room temperature, mealy breakdown developed in 23 percent of the fruit stored in an atmosphere of 3 percent CO<sub>2</sub> and 3 percent O<sub>2</sub> (3/3) at 100 percent RH, in 28 percent of that in a 6/3 atmosphere at 100 percent RH, and in only 4 percent of that held in a 6/3 atmosphere at 70 percent RH. Although lowering the relative humidity reduced mealy breakdown, the fruit held at the lower RH lost about 3.5 times as much weight as that held at the higher RH.

Fruit held at 100 percent RH in the 6/3 atmosphere was firmer and slightly greener than that held in the 3/3 atmosphere. Fruit held in the 6/3 atmosphere at 70 percent RH was similar in color and firmness to that held in the same atmosphere at 100 percent RH.

3. Plums. California-grown Nubiana and Santa Rosa plums were sorted at harvest into groups differing in specific gravity and soluble solids by flotation in a graded series of sodium chloride solutions ranging from 4 to 10 percent NaCl. Specific gravities ranged from 1.03 to 1.07. Plums with high specific gravity and soluble solids had the best flavor and quality after ripening.

Nubiana plums stored in sealed, polyethylene box liners (1.5 mil) at 32° F., developed modified atmospheres of 7 percent CO<sub>2</sub> and 12 percent O<sub>2</sub>, which reduced the rate of ripening in storage and during subsequent holding at 70° F. After 10 weeks' storage, plums held under modified atmosphere were not of high quality, but were much better in all respects than plums held in a normal atmosphere. The plums stored in modified atmosphere were harder, had lighter flesh color, had one-half as much decay, and had much better flavor than plums in normal atmosphere.

#### D. Quality maintenance during transportation

1. Pears. Transit temperatures of early-season California Bartlett pears were correlated with time required to ripen the fruit after arrival at markets in New York City and Chicago. Early fruit, shipped to Chicago, required excessive ripening periods, even when a minimum amount of refrigeration was used in transit.

Single bunker cars, which use ice as a refrigerant and have thermostatically controlled fans, provided more nearly uniform load temperatures than standard ice cars. These cars were equipped with a ceiling duct to provide better air distribution in the car. Proper spacing of containers in the load was necessary to prevent cold air from bypassing the load and prematurely shutting off the thermostat.



2. Strawberries. A series of experiments at Fresno, California simulating transit conditions for strawberries indicated that a mixture of 1-1-1 trichloroethane and dichloromethane sold commercially as Safe Delivery Vapor (SDV) was ineffective in controlling either Botrytis or Rhizopus rot of strawberries when used alone or in combination with carbon dioxide. This confirms the results of two shipping tests made with commercial loads during 1962.

Laboratory tests simulating the recommended carbon dioxide (dry ice) treatment during transit showed marked reduction in decay, compared to untreated controls. These experiments also demonstrated the danger of too high concentrations of carbon dioxide; concentrations above 50 percent for more than a few hours produced off-flavors. Good decay control was observed at about 30 percent CO<sub>2</sub>, the maximum level likely to occur in rail car loads of strawberries treated with dry ice.

3. Grapes. Thompson Seedless grapes packed in 28-pound TKV lugs were hydrocooled for 10 minutes and fumigated with 1.0 or 0.5 percent SO<sub>2</sub>. The half-cooling time varied from 1 to 2 minutes. After 2 months' storage, weight loss from hydrocooled grapes averaged 0.5 pounds while that from comparable air-cooled fruit was about 1.8 pounds. The stems and berries were fresher in the hydrocooled fruit but 16 percent of the berries were split, compared to only 1.0 percent in the air-cooled fruit. Decay was similar in hydrocooled and air-cooled fruit.

Ribier grapes that were hydrocooled and stored 5½ months lost less weight and were slightly crisper and fresher looking than air-cooled fruit. However, wet berries were found in the center of some clusters in the hydrocooled fruit; wetness was more prevalent in fruit fumigated with 1.0 percent than with 0.5 percent SO<sub>2</sub>. Decay was similar in the two lots of fruit.

Emperor grapes that were hydrocooled and stored at 32° F. for 40 days had greener and fresher stems and firmer and crisper berries than comparable fruit cooled initially in air. The color of hydrocooled fruit was brighter due to removal of dust from the berries. After 4 months' storage, the hydrocooled fruit was still in better condition than air-cooled fruit. Decay, mostly Alternaria, was not significantly different in hydrocooled or air-cooled fruit.

4. Peaches. Observations were made on test shipments of South Carolina-grown Dixie Red and Coronet peaches to London and in one containerized military shipment of Coronet peaches to Germany. Transit temperatures ranged from 38° to 45° F., rather than the recommended 32° F. The Dixie Reds showed ripening of the flesh

one-fourth to one-half inch under the skin during transit. During the 4-day 60° to 65° ripening period at destination about 30 percent of the Dixie Reds developed brown rot. The fruit was mealy and lacking in flavor. The Coronets arrived with excellent appearance; showing little or no decay or bruising. During the 4-day 60° to 65° holding period, less than 1 percent decay developed.

Little difference in mechanical damage was noted between peaches in the 22-pound wooden containers and those in the fiberboard packages. However, considerable pilferage (average of 5 percent) occurred in the cartons. Fruit in bushel baskets showed three times as much mechanical damage as that in the 4/5-bushel wirebound crates. (Exploratory Research)

5. Simulated Transit in Nitrogen Atmosphere. Continued tests at Beltsville indicate that strawberries developed less decay at 33° F. in 100% nitrogen than in 99% nitrogen or in air. After treatment for 10 days, approximately 85% of the berries remained sound in the 100%-nitrogen atmosphere, as compared to about 48% sound in 99%-nitrogen and in air. Flavor of strawberries was not affected by holding in 99 or 100% nitrogen at 33° for periods up to 10 days.

At Fresno, California oxygen concentrations of 1 percent or above had very little effect on rate of ripening, respiratory activity, flavor, or decay of strawberries. An oxygen concentration of 0.5% inhibited the rate of respiration and ripening but had little effect on flavor. The effect on decay was not determined. Zero oxygen inhibited ripening and the development of decay, but produced off-flavors with prolonged holding.

#### E. Postharvest physiology

1. Apple Scald. At Beltsville, Red Delicious and Red Rome apples were separated into high, medium, and low internal chlorophyll content categories by light-transmittance techniques before storage. This was done for two pickings 10 days apart. Scald determinations made after 6 months at 32° F. plus 6 days at 70° showed that initial chlorophyll content was not a reliable indicator of scald susceptibility. Even low-chlorophyll apples from the first picking developed much scald. At the second (commercial picking) date, both high and medium chlorophyll content apples developed similar amounts of scald. Diphenylamine, used as a dip at 2000 ppm, was an effective scald inhibitor for high, medium, or low chlorophyll content apples, particularly when fruit was picked at a commercially acceptable date.

The two approved chemical scald inhibitors, ethoxyquin (Stop-Scald) and 83% wettable powder diphenylamine (DPA) were tested on Red Delicious, Stayman and Rome apples from commercial orchards. DPA

formulations from two sources were compared. Total scald in 8 tests after 5-7 months' storage at 32° F. averaged as follows: untreated, 56%; 2700 ppm Stop-Scald, 6%; 2000 ppm DPA 10% from one source and 14% from the other. Chemical injury from the scald inhibitors was negligible and keeping quality of fruit treated with the different inhibitors was otherwise similar. In a controlled-atmosphere storage in Pennsylvania, both Stop-Scald and DPA completely controlled scald on Stayman apples, while 64% of the untreated fruit was scalded after 7 months at 32° plus 7 days at 70°. The CA Staymans were 2 pounds firmer than similar apples in air storage on removal and 1 pound firmer after 7 days at 70°.

Dipping apples in 120°-130° F. water for 1-2 minutes before storage reduced subsequent scald development on Delicious, Stayman, Rome, and York varieties. The best control of scald with hot water was obtained on Stayman apples. Time-temperature tolerance of hot-water treatments for controlling scald was critical for apples and varied with varieties. They may vary too much for commercial application. Hot water dips of 20-30 seconds at 140° or 5 seconds at 150° usually injured the skin.

An attempt was made to learn more about the mechanism involved in the control of apple scald with DPA by studying the inhibitory effects of DPA on the cytochrome electron chain. Earlier work indicated that DPA inhibited respiration insensitive to antimycin A and cyanide. Aged washed potato disks develop a type of respiration highly resistant to cyanide but sensitive to DPA. The antioxidants, butylated hydroxyanisole and butylated hydroxytoluene affected respiration very similarly to DPA. These findings indicate that the activity of DPA may be due to the formation of a reactive radical plus a hydrogen atom. This work has special significance in the study of cyanide-resistant respiration as well as the coupled phosphorylated pathway.

2. Apple Respiration in Modified Atmospheres. Additional information developed at the Ditton Laboratory in England under P. L. 480 shows that reducing oxygen to only 10 percent causes a definite reduction in respiratory activity of Cox's Orange Pippin apples in CO<sub>2</sub> free atmospheres. The data also indicate that CO<sub>2</sub> evolution is reduced more in atmospheres containing above normal amounts of CO<sub>2</sub> than in those free of added CO<sub>2</sub>. Significant data have been obtained on aldehyde and alcohol accumulation in apple tissues as related to storage atmosphere. Rather surprisingly both aldehyde and alcohol content after storage at 32° F. were lower in 2% O<sub>2</sub> than in higher controlled O<sub>2</sub> or in air. This indicates that O<sub>2</sub> must be very low before anaerobic respiration occurs at 32°.



3. Anjou Pear Scald. The first season's results on this contract research at Oregon State University include useful information on relation of field temperatures during maturation and harvest maturity to scald susceptibility. Induced temperature increases to maturing fruits increased susceptibility to scald. Three pickings at weekly intervals indicated no consistent relationship between harvest maturity and scald development in storage.

Oiled wraps were compared with dips of Diphenylamine and Santoquin and also with wraps containing these compounds. Scald was severe on all untreated fruit. Santoquin applied as a dip or in wraps gave near perfect control. Diphenylamine as a dip or in wraps gave variable results from excellent to poor. Pears wrapped in oiled wraps were about 75% scald free after storage.

4. Lenticel Spotting of Golden Delicious Apples. Golden Delicious apples of 3 color classes, yellow, white and green, were stored at 31° and 35° F. at Wenatchee with and without polyethylene liners for approximately 1 month before they were packed. The fruit was then packed without wraps, in molded pulp trays and perforated polyethylene liners in telescope fiberboard cartons. Only a small percentage of the fruit developed the disorder in one make of tray, while a relatively large percentage developed the disorder in the other make. Somewhat more injury developed at 35° than at 31°. It was most severe on yellow fruit, intermediate on white, and least on green. Although a third make of trays were not included in the laboratory experiments, observations on fruit packed commercially in these trays revealed a considerable amount of lenticel injury. A melamine-formaldehyde wet-strength resin was used in the manufacture of 2 makes of trays. Reports of work done on this problem in South Africa indicate that decomposition products of this resin are responsible for this disorder. The manufacturers of the trays have been informed of these data and have changed the resin used in trays manufactured for the 1963 crop of fruit.

#### F. Postharvest disease control

1. Apples. Ten grower lots each of Delicious and Winesap apples were selected at random from the lots being assayed in the central culture room of a cold storage warehouse. The fruit was examined after 21, 28, and 35 days at 70° F. The amount of decay in these lots ranged from 2 to 5 percent, mostly blue mold rot in the first two examinations. After 35 days the decay picture was obscured by the development of pink mold rot, (*Cephalothecium roseum*) a high temperature organism which does not develop at cold storage temperatures. Samples of the same fruit held in cold storage were examined at 120, 150, 180, and 210 days. The amounts of decay in these lots of fruit ranged from 1 to 3 percent blue mold. In the lots containing water core the amount of breakdown that developed after 210

days in cold storage was only slightly less than that which developed after 28 days at 70°. (MQ 2-67)

2. Peaches. Twenty-three tests with hot-water-treated peaches included in commercial shipments from Georgia and South Carolina to northern markets were made during the summer of 1963. On arrival the peaches were held at 70° F. until they were eating ripe. In nine tests from Georgia non-heated, hydrocooled peaches developed an average of 24 percent brown rot, whereas an average of only 7 percent brown rot developed on peaches heated in 130° water before hydrocooling. The non-heated, non-hydrocooled peaches in these tests averaged 46 percent brown rot, while the heated, non-hydrocooled ones averaged 12 percent. In eight of the tests from South Carolina the non-heated peaches averaged about 5 percent brown rot and the hot-water-treated ones about 2 percent. Rhizopus rot in both Georgia and South Carolina test peaches was reduced by about one-third by the hot water treatments.

In 6 of the 23 tests, either brown rot or Rhizopus rot or both were greater in the hot-water-treated and hydrocooled peaches than in comparable non-heated peaches. Recontamination of the fruit during hydrocooling was suspected, since the hydrocooling water at the sheds in which the 6 tests originated was extremely dirty. This indicated that hot-water-treated peaches were more susceptible to infection in contaminated water than non-heated ones.

In supplemental tests at Beltsville peaches treated with hot water and hydrocooled in water containing brown rot or Rhizopus spores developed far more decay during holding at 50° and 70° F. than non-heated fruit. When 100 ppm chlorine was added to the hydrocooling water containing the spores, the heated peaches no longer developed increased decay. None of the spores from samples of the chlorinated water germinated when plated on agar and incubated in dishes at 70°. This demonstrates the need for careful sanitation in peach packing sheds if hot water treatments are to be effective.

In many of the test shipments a mottling type of injury appeared on some of the heat treated fruit. In most instances it was not severe enough to affect the acceptance of the fruit.

About 40 truckloads of peaches were treated in a hot water tank installed in a commercial packing house in Georgia. All treated loads were commercially acceptable, whereas other shipments during the same period often developed considerable decay. (MQ 2-22)

The effect of relative humidity on the survival of Monilinia or Rhizopus spores exposed to 120°, 130°, or 140° F. air was studied under laboratory conditions. When the relative humidity was 50 percent spores of either organism exposed 4 hours at any of the

three temperatures germinated almost as well as 70° at non-heated spores. However, when the relative humidity was raised to 80 percent, spores exposed for 2 hours had much lower viability than non-heated spores. Spores exposed to 90 percent relative humidity for 1 hour at any of the three exposure temperatures had less than 5 percent germination at 70°.

Studies were continued at Chicago on an organism belonging to the genus *Phytophthora* which was isolated from Indiana peaches in 1962. The organism infects peaches through wounds or by contact. Mature sporangia placed in water at 40° F. readily form and release zoospores which retain motility for 5-10 minutes after release from sporangia. Germination of zoospores at 70-80° F. occurs 3/4-1 hour after escape from sporangia.

3. **Grapes.** The distribution of SO<sub>2</sub> in conventional ice bunker refrigerator cars was determined when the car fans were operating. Distribution was poor when air was allowed to move freely through the floor racks at the brace, but a reasonably uniform concentration of SO<sub>2</sub> was obtained throughout the load when the floor rack was covered with paper to prevent by-passing of the SO<sub>2</sub> and air. Use of 2 percent salt to increase ice meltage increased SO<sub>2</sub> absorption by the melting ice to 20% more than ice without salt. Additional amounts of SO<sub>2</sub> were required to compensate for that removed by the ice water.

Respiration rates were compared for Emperor grapes fumigated at weekly intervals for 3 months with 0.1, 0.25, 0.5, or 1.0 percent SO<sub>2</sub>. The respiration rate decreased progressively with increasing concentrations of SO<sub>2</sub>. When berries from each treatment were immersed in water, the conductivity of the water increased with increased concentration of gas and also increased with the number of fumigations. This may be an indication of the degree of injury induced by SO<sub>2</sub>.

After 6 weeks' storage, the capstems of Emperor grape berries, that were not fumigated with SO<sub>2</sub>, were all infected with *Alternaria*. Only 6.4 percent of those fumigated with SO<sub>2</sub> were infected. When the brush was severed from the capstem, 74 percent of the brushes from the non-fumigated berries were infected and only 1.6 percent of the fumigated ones. No difference in *Alternaria* infection was found in grapes fumigated with 0.1, 0.25, 0.5, or 1.0 percent SO<sub>2</sub>.

Berries inoculated with *Botrytis* were incubated for 18 hours at 50° F. and then dipped for 1 or 2 minutes in water containing 7.5, 6.0, 4.6, 2.8, or 0 percent dissolved SO<sub>2</sub>. After 5 days at 50° F. berries dipped in water with no SO<sub>2</sub> were all decayed, but those dipped in any of the SO<sub>2</sub> solutions were free of decay. However,



all concentrations of SO<sub>2</sub>, except the 2.8 percent, injured the fruit. Dipping the berries in a 2.0 percent sodium bisulfite solution also controlled decay, but left a residue on the skin.

4. Blueberries. Berries from Maryland, New Jersey and North Carolina were dipped in hot water and in various fungicides before storage at Beltsville to evaluate effect on decay. Certain hot-water treatments were more effective than the fungicides in reducing decay, principally gray mold. Total decay after 4 days at 50° F. plus 7 days at 70° in six laboratory tests averaged 30% or more, when untreated, or dipped in 80° to 110° water, 1000 ppm Botran, or 0.5% sodium salt of dehydroacetic acid. When dipped 5 minutes in 120° water, 2 minutes at 125°, or 1 minute at 130°, decay ranged from 5 to 8%. A 30-second dip in 140° water severely damaged the appearance by removing the bloom. Slight heat injury occurred on fruit treated in 120 to 130° water in some tests. Fumigation with 0.25% SO<sub>2</sub> for 20 minutes reduced decay in some tests but injured the fruit.

Unsatisfactory results were obtained in 3 tests with hot-water treatments at commercial blueberry packing sheds in New Jersey. Spoilage, largely from *Rhizopus* rot, was more than doubled by the hot-water treatments. Apparently the berries were injured by the heat treatments and then were heavily contaminated with *Rhizopus*. Later tests showed that drying the berries after treating with hot water reduced decay appreciably.

5. Cherries for Brining. The optimum pH of pectinase activities for the juice extracted from cherries rotted by *Cytospora leucostoma*, *Aspergillus niger* and *Penicillium expansum* were pH 3.0, 4.5, and 6.0, respectively. Tests for galacturonic acid were positive for all organisms. Incubation of enzymes in the presence of bisulfite brine reduced activity by 1.5, 2.2, and 8.9%, respectively for *Cytospora*, *Penicillium*, and *Aspergillus*. This work has been completed.

6. Red Raspberries. Fumigation with 0.25% SO<sub>2</sub> gas for 20 minutes or a 30-second dip in 0.5% sodium salt of dehydroacetic acid substantially reduced decay. In ten tests at Beltsville salable berries after 4 days at 60° F. were as follows: Nontreated 42%; dipped in room temperature water 25%; dipped for 30 seconds in .5% sodium salt of dehydroacetic acid 78%; treated with .25% SO<sub>2</sub> gas for 20 minutes 63%.

7. Cranberries. A series of hot water treatments were evaluated as a means of reducing spoilage of cranberries in storage. Cranberries immersed in 125°, 120°, 115° and 110° F. water for 2.5, 5, 10 and

20 minutes, respectively developed about one-half as much spoilage over a 6-month storage period at 38° plus 7 days at 70° than non-treated berries. Also, cranberries stored continuously at 70° after the hot water treatments developed significantly less spoilage after 6 weeks than non-treated berries.

8. Strawberries. Market surveys have shown the presence of Phytophthora and Rhizoctonia spp. on California strawberries. These diseases have not been heretofore reported from California.

9. Gamma Radiation Treatments. Through an arrangement between the U. S. Atomic Energy Commission and Atomic Energy of Canada, a mobile irradiator (cobalt source) was made available to the Fresno, California laboratory last June. During the summer and fall of 1963 this has been used to determine, on a pilot scale, the value of gamma irradiation for the control of spoilage in fruits and vegetables and for its effects on the ripening and quality of the products discussed below:

(a) Plums--Four plum varieties, Santa Rosa, Eldorado, Laroda, and Wickson, were irradiated with doses of 125 to 500 krad. Color development was inhibited in proportion to the dose in all varieties. The irradiated fruit softened more rapidly than the untreated and developed very little flavor as it ripened. When ripened immediately after irradiation, only the Wickson plum was obviously injured, but after 2 to 6 weeks' storage, none of the irradiated fruit ripened as well as the controls; plums treated at the higher doses were inedible.

(b) Strawberries--Two varieties of strawberries, Shasta and Z5A, from the Salinas-Watsonville area were irradiated with doses of 100 to 300 krad. Decay due to Botrytis, Rhizopus, and Phytophthora was sharply reduced by doses of 200 to 300 krad. The Z5A variety was injured slightly by 300 krad.

(c) Peaches--Cardinal, Red Globe, Suncrest, and Fay Elberta peaches were treated with doses of 45, 125, 200, and 300 krad of gamma irradiation. Response varied with varieties. Cardinal peaches were injured by even the lowest dose and Rhizopus rot increased as a result. Decay did not develop appreciably in any other variety. The effect of irradiation on softening was inconsistent; irradiated Cardinal and Red Globe fruits became softer than untreated fruit; irradiated Suncrest softened less, and there was little effect on Fay Elberta. Doses of 125 krad or higher increased the development of red color during storage. However, doses of 200 and 300 krad produced a distinct loss of flavor.

(d) Nectarines--Sun Grand nectarines were treated with doses of 45, 125, 200, and 300 krad. There was no apparent beneficial effect of irradiation. Firmness was not influenced. Increasing doses resulted in increasing redness of the fruits, but also in a progressive loss of flavor. No decay developed in either treated or untreated fruit.

(e) Pears--Bartlett pears irradiated at 100, 200, 300, and 400 krad were harder and retained more green color than untreated fruit after 6 days at 60° F. Among the irradiated lots, the fruit treated with the lowest dose was the hardest and the greenest. After an additional 4 days the fruit in the lot having the low dose had ripened more rapidly than the higher doses.

10. Pesticide Residues. A P.L. 480 project underway in Finland has developed additional information on residues of captan, malathion, particularly as related to absorption and disappearance of these materials from plant tissues. Using labeled isotopes they have followed translocation of malathion by autoradiography.

Studies on CIPC and IPC analyses and residues were initiated during the past year. Accurate methods of analysis have been devised and residue studies are underway with plums, apples, and some vegetables. Tests to date indicate that residues of these two compounds are relatively stable in stored products. A new series of tests is underway to determine the effects of malathion, captan, CIPC and IPC on storage life and decay development in fruits.

## G. Prevention of insect infestation

1. Insecticide Evaluation. A proportionate share of the program at Savannah, Georgia, has been charged to this area. Although much of the work is directly applicable, it is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore the entire report is included in Area 13.

2. Insecticidal Control. A single early application of 2-percent endrin dust on grape vines at the rate of 50 pounds per acre at the time the first vinegar fly infestation appeared failed to give any control, based on the amount of clean grapes harvested. Two treatments of 4-percent naled dust at 50 pounds per acre, applied 1 week apart and starting 2 weeks after the first infestation appeared, held the increase of infested grape clusters to 7 percent. There was a 16-percent increase of infested clusters in untreated grapes. A combination of the early endrin treatment and 2 subsequent naled treatments permitted an increase of only 3 percent of infested clusters. An alysis of data obtained the last two years shows that



timing of insecticidal dust applications and the degree of infestation at the time of the first treatment are more important factors for successful control than are the kind of insecticide or application rate, when the insecticides are dibrom, dimethoate, endrin, malathion, or naled, and the application rates are 35 or 50 pounds per acre. The dust treatments not only reduced vinegar fly infestations but indirectly reduced the spread of bunch rot, which is the most serious disease of ripening grapes in California. This in turn increased the yield of harvestable grapes.

DDVP has given promising results in some preliminary tests against vinegar flies in wineries. Static cylinders releasing a steady known amount of DDVP vapor gave consistent kills of the flies but the cylinders were apparently not used in sufficient numbers to produce enough vapor for complete control. DDVP aerosol was applied in some large wine storage rooms. Fly trap counts indicated good control for 3 to 5 days after treatment. Air samples taken immediately after treatment and analyzed for DDVP showed a great variation in concentration in different parts of these large rooms. Studies will be continued to find ways to get higher concentrations or more uniform distribution of the DDVP vapor, thereby improving the fly control.

Preliminary studies with malathion-treated raisin drying trays for the 1961 crop gave highly promising results and created great interest in the industry. An expanded study was conducted on the 1962 crop with trays containing 33, 150, and 300 mg. of malathion per square foot and untreated trays for controls. At the end of the drying period about 70 percent of the insects attracted by the drying grapes and found on untreated trays were alive. Nearly 100 percent of the insects found on treated trays were dead. At least 12 species of insects were found on the trays. In a supplemental test uninjured and field-run grapes were placed on malathion-treated trays to dry. At the end of the drying period over 80 times as many insects were found on the trays of field-run grapes as on the uninjured ones.

Chemical analyses of malathion-treated raisin trays at the time they were put in use and at the end of the drying period showed a reduction in malathion deposit during that period to one-tenth to one-twentieth the original level. At the same time malathion was being deposited on or in the raisins. After drying, some raisins were placed in "biscuit rolls" and some in "cigarette rolls." Those in the former type contained 2 or 3 times more malathion when they were removed from the rolls. Additional tests will be conducted on the 1963 crop to find whether the same results are obtained.

The test raisins were placed in typical farm storage upon removal from the field. Samples were taken at that time and after 3, 6, and 9 months of storage for chemical residue analyses. Samples were also processed at intervals to determine the amount of malathion removed during processing. Processed raisins containing 9.6 ppm of malathion were subjected to flavor and odor tests by an expert panel. No adverse flavor or odor attributable to malathion was detected by the panel. The chemical residue data and other pertinent information are to be considered by the Food and Drug Administration in connection with a petition for a malathion tolerance that would permit the commercial use of malathion-treated raisin drying trays. Such trays should not be used until or unless a tolerance is established.

Observations were made on the status of insect infestation in the raisins during the 9 months of farm storage. At the end of that time the insect population seemed to be increasing in the raisins that had been dried on trays containing 33 mg. per sq. ft., but there were still only about one-fourth as many as in the raisins from untreated trays. Raisins from trays with 150 or 300 mg. of malathion per sq. ft. were almost completely free of any living insects after 9 months of storage. Laboratory bio-assay tests indicated that as little as 2 ppm of malathion on raisins will prevent the development of the Indian-meal moth and the saw-toothed grain beetle, two major pests of stored raisins.

Fumigation studies relating to stored tree nuts were deferred during this reporting period to give emphasis to the raisin tray work.

3. Insecticide Residue Analysis. The cross-commodity residue analysis work at Savannah, Georgia, is reported in Area 13. Some analyses were also conducted by industry cooperators.

4. Insect-Resistant Packaging. The cross-commodity packaging research at Savannah, Georgia, is reported in Area 13.

A cooperative study between the Fresno and Savannah stations was designed to determine the ability of insects to invade packages used by the date industry. The types of packaging evaluated were a plastic cup with a friction-lock lid, a plastic cup with polyethylene lid, and boat-pack containers with overwrap. The Fresno phase of the study has not been completed. Replicated groups of the filled containers were exposed for 6 months to heavy populations of stored-product insects at Savannah. A few of the boat-pack containers were invaded by insects, apparently through faulty end seals. The other containers remained insect free.

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TRANSPORTATION AND MARKETING FACILITIES  
Transportation and Facilities Research Division, AMS

Problem. Returns to producers and prices paid by consumers for deciduous fruit and tree nuts are adversely affected by the use of inefficient marketing facilities, equipment, and methods. Better work methods, techniques, devices, operating procedures, equipment, and facility designs are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing deciduous fruit and tree nuts. Such improvements are needed at both shipping points, and terminal markets. They would increase the productivity of labor, prolong the storage life of the commodities, reduce bruises and injuries to these products, reduce marketing costs, expand consumption, and reflect greater returns to producers.

It costs about 8 billion dollars a year to package food products, but without shipping containers and various other types of packages it would be impossible to move farm products efficiently from the widely dispersed areas of production through our complex marketing system to millions of consumers. New or improved packages and containers must be developed and evaluated to do this job more effectively. Continuing changes characterized the American marketing system. In protecting, distributing and selling perishable agricultural commodities, packages and containers must respond to a number of marketing system changes. Packages and containers not only respond to changes, but changes in them stimulate improvements in other elements of the marketing system. The job of the research program in this area is to see that packages and containers keep pace with changes in the marketing system and reduce the cost of handling, transporting and storing agricultural commodities. It also seeks to improve service to consumers, promote greater sales of farm products, and increase the income of producers.

It costs several billion dollars each year to transport farm products over the great distances between growing areas and consumers. In bridging this distance, products must normally be transported several times (farm to local assembly market, to warehouse, to terminal market, and thence to retail stores). Rail, truck, air, and water transport are used. Without this transportation, farm products would be worth little to farmers and nothing to consumers. Despite its importance, less has been done to improve the efficiency of transportation than for other aspects of marketing or farming.



## USDA PROGRAM

This is a continuing long-range program involving engineering research covering the development of improved work methods, techniques, devices, operating procedures, equipment, and facility designs for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing deciduous fruits. Deciduous fruit research is carried on by the Wenatchee, Wash., and Athens, Ga., field offices and by the Washington office; in both laboratory and commercially-owned facilities; in the Pacific Northwest, Georgia, and Michigan, in cooperation with the Washington, Georgia, and Michigan Agricultural Experiment Stations, and the Market Quality Research Division, AMS. The current annual Federal effort devoted to research in this area totals 12.3 professional man-years of which 3.0 is on deciduous fruits.

Work on consumer packages and shipping containers is a continuing program of applied research conducted by marketing specialists, industrial engineers, and agricultural economists to (1) develop new or improved consumer packages, master containers, packing materials, and shipping containers for agricultural products; (2) evaluate them from the standpoint of cost of materials and direct labor to pack and their ability to reduce product damage and increase product salability; (3) determine at which point in the marketing system packaging can be done most effectively; (4) improve the efficiency of packaging methods to cut costs; (5) and investigate the needs for and benefits of container standardization and simplification. The program is carried on in cooperation with the experiment stations and industry in California, Oregon, South Carolina, Washington, at branch field stations in Fresno, Cal., Orlando, Fla., and Yakima, Washington. The work on deciduous fruit utilized 3.3 professional man-years.

The Department has a continuing program of economic-engineering research in agricultural transport. Its purpose is to develop improved transport facilities, equipment and services and more efficient means of using them in the production and marketing of agricultural products. Almost all the work is carried out in cooperation with various industry groups, trade associations, State Universities and experiment stations. Only one field station, Orlando, Florida, is permanently maintained for transport research. All other field work is carried out from the Washington office. Part of the research under this program is conducted under contract and cooperative agreements. The deciduous fruit work utilized 0.8 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

## Marketing Facilities, Equipment and Methods

Handling and Packing

This research is directed toward the development of more efficient work methods and equipment for handling, washing, sorting, sizing and packing apples. It includes a study of the impact of electronic color sorting of apples on related packinghouse operations and an evaluation of presizing and presorting apples in commercial storages and packinghouses.

1. At Wenatchee, Wash., research consisted of observing the operations of electronic color sorting and preparing layouts of facilities where electronic color sorters were installed. Because the electronic color sorter was plagued with mechanical trouble throughout the packing season, it was not possible to make detailed studies of the equipment's operation. Preliminary studies show that: (1) The electronic color sorter is yet to be mechanically perfected so that it will give consistent, dependable service; (2) it is still too expensive for any but the largest commercial apple packers; and (3) the sorter does an excellent job of separating fruit by degrees of surface color with both red and yellow varieties.

This research involves a case study of the one packinghouse in the Pacific Northwest known to presort and presize apples for storage. Work sampling studies were made of the resorting operation and time studies were made of packing operations involving fruit that had been pregraded. These data were summarized and analyzed. All of the presorting and presizing was done on equipment designed for conventional operations with orchard-run fruit. The result was a relatively high amount of bruising of the presorted-presize fruit, necessitating an essentially full-scale resorting operation at time of packing. It became evident that equipment in current use was not satisfactory for presorting and presizing apples, and that new equipment designed specifically for presorting and presizing would be needed.

A new packing line was designed to meet the requirements of a presorting-presizing operation, and preliminary drawings have been completed. This line is expected to handle the high volumes essential to a presorting operation, and to handle the fruit with much less bruising. It is expected further that this line would be suitable for apples, peaches, pears, and plums; whereas, existing lines are satisfactory only for apples. Designs for a new unitized packing line provide for sorting, brushing, drying, and sizing of fruit, as well as for cleaning and disinfecting of brushes after each use. Limited design work was done on a deep-tank water dumper, and a water filler for pallet boxes.

2. At East Lansing, Mich., under a cooperative agreement with the State Station, research was continued toward designing, constructing a prototype, and testing equipment which uses water as a medium for dumping, sorting, sizing, and filling apples back into pallet boxes. Experimental apparatus was built which involved a large tank and a very high capacity water pump. Methods of sizing, either by floating the fruit to the surface or by floating the fruit past a revolving expanding helical, were investigated. Tests indicated that floating the fruit up through a submerged mesh chain-type sizer gave the best results. In connection with this, observations were made of the velocity of the fruit as it rises toward the surface. A study of the amount of water penetrating the fruit submerged to different levels indicated that, for the shallow depths of water needed, little or no penetration occurs. As a consequence, this method should not be conducive to bacteria entering the fruit and causing serious breakdown.



A model reverse-roll sorting table was constructed and tested using lanes for separation of two grades of fruit. Its operation was satisfactory, but the cull lanes occupied approximately one-third of the table width, which limits the capacity. Other sorting methods were therefore devised for testing.

One-bushel capacity models of three types of pallet box refillers were built and tested. The three types were: (1) Direct fill; (2) reverse of hydro dumper; and (3) flume type. The direct fill type, using a flighted belt submerging conveyor was quite successful except for holding all the fruit as the box was rotated. With some modifications, such as adding a mechanically-operated gate, this method might prove satisfactory. The reverse of the hydro-dumper method also looks promising. This method employs a submerged accumulator of smaller dimension than the box to be filled. The flume-type filler, utilizing water flow accompanying the fruit down a gently sloping flume to fill the box from the top, appears unsatisfactory because of bruise damage. Even with careful control, it is almost impossible to prevent impact of incoming fruit on that buoyed up by the water. The resulting bruising is almost as severe as if there were no water supporting the fruit in the box.

One fact noted is that any type of water fill leaves more and larger voids between fruits and generally gives a poorer fill than an air-gravity fill. Attempts to use vibrations and/or turbulent flow through the boxes during transfer proved unsatisfactory in giving better fill.

3. In the Washington office, a manuscript, based on contract work, entitled, "Apple Packing Methods and Equipment" was partially completed. This report will contain an up-to-date analyses of currently used methods and equipment for dumping, washing, brushing, sorting, sizing, and packing apples.

### Storage

1. Cooling Rates. The purposes of this research, at Wenatchee, Wash., are to: (1) Measure and evaluate the cooling rates of fruits in storage and shipping containers in terms of container designs that properly protect the fruit, shorten the cooling period, and maintain the fruit at proper storage temperatures; and (2) develop improved handling, stacking, and storage practices.

A cooling study of pears packed in fiberboard containers and standard wood lugs was made at the Skookum Storage in Wenatchee. The containers were stacked in two different patterns: (1) Close stacking where the ends of the container only were exposed to the cooling air; and (2) loose stacking where the air could circulate around the container on the two ends and two sides. Curves plotted of the cooling rates show that pears packed in fiberboard containers cooled from 55° F. to 35° F. in 117 hours when stacked loosely and 157 hours when stacked tightly. Under the same conditions, pears packed in standard wood lugs cooled from 55° F. to 35° F. in 83 hours when open stacking was used and in 91 hours when tight stacking was employed.



2. Refrigerated Storage. The objectives of this project are: (1) To investigate airflow and distribution methods, patterns, and rates in refrigerated fruit storages to determine and evaluate the influence of these factors on cooling fruit and on bringing it to optimum storage temperatures; (2) to determine and evaluate heat gains through various structural features of fruit storages and make suggestions for improved designs; and (3) redesign storage houses for the most efficient handling and storage of fruit in pallet boxes.

To check the air temperatures and fruit temperatures in a cold storage room, thermocouples were installed in the fruit and in the adjacent air at various locations in a cold storage room at the time apples were placed in the storage which is located at Chelan Station. Temperature and humidity readings were taken once a week until the temperatures had stabilized, then twice a month. The temperatures were maintained as low as possible without freezing the apples.

The apples were sampled and pressure tested on January 16, 1963, and again on April 4, 1963. There was a considerable drop in firmness between January 1 and April 4, as shown by the tests; however, when the apples were removed from the storage, the apples farthest from the aisle were considerably firmer than those adjacent to the aisle, indicating better keeping quality where the air was the coldest. These apples brought top prices on the market and were equal to best quality apples from controlled atmosphere storage (C.A.). Only selected fruit of high quality was placed in this storage, the same as would be placed in controlled atmosphere storage.

The manuscript for a report, "Apple Packing and Storage Houses--Layouts and Designs" was edited for publication and sent to the Government Printing Office.

3. Controlled Atmosphere Storage of Apples. Work on this project is designed to develop improved methods, techniques, equipment, and facilities for the controlled atmosphere (C.A.) storage of apples in the Pacific Northwest.

As in former years, studies of controlled-atmosphere storage were carried on in the laboratory in conjunction with the Horticultural Crops Branch, MQRD, AMS.

Comparative tests this past season were made as follows: From a composite lot of fruit picked at the same time, samples were placed in regular storage, conventional C.A. storage, and in a Tetrol (Whirlpool Corp.) C.A. storage. When tested for comparison in May 1963, the differences in the fruit were so slight that an unskilled person would not have been able to tell from which storage the apples had come. The pressure tester indicated 17.1 lbs. for the regular C.A. storage apples, 16.9 for regular refrigerated storage, and 16.0 for Tetrol C.A. apples.

The taste panel of six members could distinguish but little difference in the samples. This indicates, as in the past, that the advantages of C.A. storage for Delicious apples are questionable, and that sharpening up the practices used in regular cold storages should accomplish as much in maintaining quality as C.A., but with less expense.

It is reported that there were 32 C.A. storages operating in the State of Washington during the past storage season. In capacity, the storages vary from 25,000 to 196,000 bushels held unpacked in pallet boxes. There were 2,119 equivalent carloads of fruit in storage at the beginning of the season. The Washington State Apple Commission in their report, Market-VU report for April 26, makes the following statement: "Almost without exception the C.A. fruit which has arrived here at the Auction has brought considerably less than f.o.b. prices, and at Wednesday's sale, there were lots of regular storage apples of familiar auction brands which brought more than C.A. apples of similar grade and variety."

### Cooling

This research is designed to develop improved methods, equipment, operating practices, and techniques for use in existing or new facilities for more efficient cooling of deciduous fruits.

At Wenatchee, Wash., one test was run during the Fall on hydrocooled apples at an apple packing plant in Washington. This hydrocooler was approximately 8-feet wide and 90-feet long. The apples were dumped in at one end, floated the length of the hydrocooler, and at the other end were elevated directly to two sorting lines and then to the sizer and packing line. This test will be repeated during the next season to determine the amount of heat removed in apples of different sizes.

During the summer of 1962, one study was made on gift packages of cherries to determine the length of time for packages to warm up under different conditions. This study was made of cherries packed in gift packages then precooled before mailing them to various destinations throughout the United States. Previous studies had indicated that the warmup time could be delayed if the packages were insulated. Test packages were insulated with one inch and two inches of styrofoam insulation, respectively. The data show that the standard cherry gift package warmed from 32° F. to 60° F. in 7.8 hours when the average room temperature was 83.2° F. Under the same conditions the gift package having one inch of insulation warmed to 60° F. in 14.1 hours and when insulated with two inches of styrofoam the time was 18.7 hours. This was a delay in warmup time of 181 percent and 240 percent respectively over the standard gift package. One inch styrofoam increased the container weight by 1 pound 3 ounces and the 2-inch styrofoam increased the container weight by 2 pounds 6 ounces.

In cooperation with a commercial supplier of nitrogen, a study was made on cooling a peach storage room with nitrogen gas. The storage room was approximately 50-feet long, 50-feet wide, and 20-feet high. Liquid nitrogen was injected directly into the room. Although some reduction in temperature was noted, the cost was found to be prohibitive when used to remove the field heat from such a large product load.

At Athens, Ga., a wind tunnel to study the surface heat transfer coefficients of certain fruits and vegetables to air, was completed. Calibration of the test equipment and procedure, utilizing a silicone rubber of known conductivity, has not been entirely satisfactory. Nevertheless, a few preliminary test runs have yielded valuable surface transfer data.

Design of a portable experimental hydrocooler was completed. A manuscript entitled, "Owning and Operating Peach Hydrocooling Systems" was prepared.

#### Handling Grapes in Pallet Boxes

This research covers the development of improved work methods and equipment for handling Concord grapes at processing plants, and is cooperative with the Agricultural Engineering Research Division, ARS. Because of the poor grape crop in Michigan in 1962, AERD was unable to install its proposed grape-handling system in a plant for testing. Consequently, no data were obtained relative to the revised system, and no progress was made on this project.

#### Handling and Packing Fruits on Terminal Markets

1. Tiering Devices and Equipment. This research also by the Washington office was directed toward reducing the cost of storing fruits and vegetables at the wholesale level by increasing the utilization of available storage space in wholesale fruit and vegetable warehouses.

The manuscript, "Storing Fruits and Vegetables on Pallets in Wholesale Warehouses," was edited for publication and forwarded to the Government Printing Office for printing.

2. Handling Operations for Multiple-Occupancy Facilities. The purpose of this research by the Washington office was to determine the combinations of crew sizes, operating methods, types of handling equipment, stacking or storage patterns, and facility layouts that will minimize the total cost of moving selected volumes of produce into, within, and out of modern multiple-occupancy buildings occupied by wholesale distributors of fruits and vegetables and reduce floor space requirements, and thus provide criteria to TFRD's Marketing Facilities Planning Staff for its work in specific areas or localities.



Work was limited to the completion of a "Survey of Fruit and Vegetable Wholesalers in Multi-Occupancy Facilities," covering 83 dealers in 11 cities in 10 different states. A summary has been prepared of the survey data, which include the business characteristic -- number of store units, annual sales, volume, seasonality of business, inventory, size, hours of operations, and services provide -- customer information -- type of customer, order size, and sale method -- and labor employed -- number of workers, wages paid, hours of work, crew size, and full or part-time workers.

Personnel assigned to this project have transferred and will not be replaced.

3. Loading Out Delivery Trucks. The purpose of this research is to evaluate and compare the relative efficiency of selected methods and types of materials handling equipment for order assembly and truckloading that are used by wholesale distributors of fresh fruits and vegetables supplying both affiliated and non-affiliated retail stores so as to reduce unit costs and minimize spoilage and waste.

This is a joint project of the Handling and Facilities Research Branch and the Wholesaling and Retailing Research Branch. Three basic types of loading out systems were studied in the warehouses of three wholesale distributors. The three methods include the use of: (1) A motorized belt conveyor with recording and transcribing equipment; (2) a motorized belt conveyor and checker system; and (3) a tow tractor and 4-wheel trucks to assemble individual orders. Preliminary analysis shows that the motorized belt conveyor with recorder and transcriber was less costly than other methods for the assembly of individual orders containing less than 55 packages. This system seems particularly suited for wholesalers supplying hotels, restaurants, institutions, specialty fruit and vegetable stores, and regular retail grocery stores. For wholesalers assembling larger than 55 packages per order, the tow tractors and 4-wheel selector trucks are the less costly. At the end of the year, a manuscript entitled, "An Evaluation of Selected Methods for Loading Out Produce in Wholesale Warehouses," which summarizes the results of this research, was in preparation for publication.

### Consumer Packages and Shipping Containers

1. Peaches. Encouraging results are now being produced by research which began 4 years ago to develop an inexpensive container which would reduce transit damage of peaches. Consumers are getting better peaches this season and growers in the southeast are receiving a higher net return for the fruit. The conventional container of growers in the southeast is a 3/4-bushel basket with bulge top, which costs 53 cents and is relatively expensive to pack. In cooperation with private industry, researchers evaluated new containers which cost less than 43 cents and can be used with high speed machine fillers. The combined savings in material and packing labor are estimated at 20 cents per 3/4-bushel of peaches. Bruising in the conventional basket averaged 12 to 13 percent. In the new containers it is less than 6 percent.

This season brought a substantial increase, not only in the tonnage shipped, but also in the number of shippers of a "family" of three packages developed in recent years by researchers: (1) A consumer package--a 4-pound till of green pulpboard--holds 18 to 20 uniformly sized peaches overwrapped with transparent film at point of production; (2) a shallow fiberboard box for larger peaches carries two layers of fruit in cupped trays; (3) the new container--a combination veneer and fiberboard wirebound crate--is packed with 3/4-bushel of peaches in a range of sizes.

Two seasons ago the southeastern growers packed only 1 percent of their peaches in the new containers. Last season, between 5 and 10 percent of the southeastern peaches went to the markets in these three containers and this season at least 50 percent were marketed in the new packages. All indications are that the peach industry and its customers, both wholesale and retail, find this "family" of packages of material help in getting the peaches into the hands of the consumers.

Most of the peaches produced this season in New Jersey, Maryland, West Virginia, and Michigan were shipped in cartons or in the combination wirebound crates. A large shipper of peaches from Maryland and West Virginia began packing peaches in consumer size packages.

This newly developed "family" of packages reduces package and packaging costs and losses from bruising. Customer acceptance has been good.

2. Apples. In four years of continuing research, the cost of materials and direct labor to prepackage northwestern apples at point of production has been reduced 27 cents per box of 16 2½-pound consumer units--or \$221 per carload of 820 boxes. A new arrangement of vertical and horizontal dividers not only gives improved protection to the apples but permits use of a lighter, less expensive master container. Strength to resist crushing is maintained by the dividers which brace both top and sidewalls. The new compartmented box accommodates a range of sizes from 80's to 125's.

In an effort to improve the condition of U. S. apples competing in overseas markets, the protective capabilities of a newly developed pad were evaluated in two preliminary test shipments. Both originated in West Virginia and both went by ship--one to London and one to Lima, Peru. Golden Delicious apples in the experimental pack with expandable crepe paper pads arrived in London with less damage and serious damage by bruising than in paired boxes of the conventional packs with moulded pulpboard trays--2.7 percent as compared with 4.5 percent. The reverse was true in Lima where Red York apples in the conventional pack arrived with no damage or serious damage while apples in the experimental pack sustained 1.7 percent damage by bruising and no serious damage. Assistants to the U. S. agricultural attaches inspected the apples in the export markets.



A rising demand has greatly stimulated plantings of Golden Delicious apples in recent years. The new trees are beginning to bear and the volume of the harvest is increasing. The soft-fleshed, highly-perishable characteristics of these apples require careful and expensive packing to prevent excessive bruising in transit. Materials alone for the cell pack with superior protective abilities cost 77 cents per box. This is about 15 cents more than materials for the conventional pulpboard tray pack for nonpackaged apples which is excellent for most varieties but sometimes fails to provide adequate protection for Golden Delicious apples.

New pads, trays, dividers, packing patterns and shipping containers are being evaluated in an attempt to develop a pack as cheap or cheaper than the tray pack and as reliable as the cell pack. Exploratory tests were begun with less expensive paper substitutes for the corrugated fiberboard material used in the cell packs. So far, the substitutes have not functioned as well as the fiberboard, especially in storage with high humidity.

3. Pears. The comparative merits of prepackaging western winter pears in trays with a complete film overwrap and with a band or sleeve strap were evaluated. The complete overwrap required more film, hence cost more. It also required expensive machinery to obtain production speeds comparable to that of a fast, manual sleeve wrap. However, packages with a complete overwrap maintained a fresh, attractive appearance longer than the sleeve wrapped packages. The condition of pears shipped to market this year in the sleeve wrap and the complete wrap was about the same.

In 1961 and 1962 test shipments of Anjou pears in a sleeve wrap of polyethylene film shrunk tight around the fruit arrived in eastern terminal markets with less than 1 percent bruising as compared with 23 percent in standard wood boxes; discoloration was 5 percent as compared with 7 percent. A higher level of bruising and discoloration in the 1963 shipments was attributed to (1) uneven ripening of the fruit in storage before shipment, and (2) experimental use of a new packing arrangement in which the wrapped consumer trays were stacked vertically in the master containers rather than alternated in different layers.

In an effort to learn more about the effect of pear maturity and alternative packing arrangements on the condition of the fruit after arrival in terminal markets, limited shipping tests and transit simulation tests were conducted. Both relatively firm and relatively mature Anjou pears were packed with varied protective treatments: (1) Consumer trays in layers alternating from a 3 x 2 pattern to a 2 x 3 pattern, with top pad and no pads between layers; (2) trays in layers without alternating patterns, with top pad and pads between layers; and (3) trays in non-alternated, compartmented packs with vertical partitions and pads between layers.



The compartmented packs and the packs with both top pads and layer pads protected pears better than packs with pads only on top. In all packs, the more mature pears sustained more damage by bruising and serious bruising than the less mature pears.

More than 70 carload equivalents of pears wrapped in shrinkable films were shipped commercially from Washington, Oregon, and California in the 1961-62 season and initial checks indicated an even larger volume during the 1962-63 season.

4. Grapes. The ability of various clear, plastic films to protect highly perishable grapes under simulated transit conditions is being tested in the laboratory of the Fresno, California, field station. The films which perform best will be used in devising a flexible consumer-size package, which provides more visibility for its contents than the window carton developed in earlier research. Presently under consideration is a perforated film bag, a polyethylene mesh bag, and a light plastic tray with a sleeve wrap of transparent film. Each would hold about two pounds of grapes.

Heretofore, almost all research was on rigid packages for table grapes. These rigid packages have had very limited success because they: (1) Did not enhance the appearance of the grapes so that trade and consumer acceptance was not good; (2) entailed relatively high expenditures for packaging materials and labor; (3) permitted the inclusion of poor quality grapes; and (4) required that bunches of grapes be cut up so that they fit the package.

Growers and packers need and have requested a flexible package that will enable them to package individual bunches of grapes either in the shed or in the field at a low cost; and that will, at the same time, enhance the appearance of the grapes.

#### Transportation Equipment and Loading Methods

Improved Loading Methods for Truck Shipments of Apples in Corrugated Fiberboard Containers. The initial results of this research were summarized in an interim report, AMS-321, entitled, "Loading Methods for Truck Shipments of Apples in Fiberboard Boxes," released in July 1959. This report covered the development and comparative effectiveness of a new "air-channel load" in reducing load disarrangement, container damage and improving refrigeration in transit.

Subsequent work included the development of improved load securing methods and materials, including load-locking devices, bracing frames and a fractionizing coating applied to containers to maintain proper row and stack alignment in the new "air-channel load" during transit.

Work demands of other projects delayed preparation of the final report. All field work has been completed and the data have been analyzed and evaluated. The initial draft report of the results is now being prepared for review and publication.

Pallet Containers. (Apples) all field work has been completed and most of the data have been analyzed and results evaluated on rail and truck shipments of apples in expendable corrugated pallet containers. Test shipments were made from Washington State to Minnesota chain store prepackaging plants to develop data on comparative handling costs and fruit bruising. Most of this work was conducted under contract by Food Industries Research and Engineering of Yakima, Washington. Information developed from additional tests conducted one year ago has been integrated with that developed under the contract work. A report has been prepared and is in the final stages of review before publication.

Pallet containers with 800 to 900 pounds of fruit makes it possible to take full advantage of using materials handling equipment for loading, unloading, and in-plant handling; and to ship more fruit per shipment through increased load density. Savings result from lower container, packing, handling, transportation and protective service costs.

This work has demonstrated that savings in shipping apples for prepackaging will amount to as much as \$400 per car when shipped in pallet containers as compared to the conventional 40 pound tray pack cartons.

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## COOPERATIVE MARKETING

### Marketing Division, FCS

Problem: Farmers continue to expand their use of cooperatives in marketing the products of their farms. In light of the rapid and complex changes taking place in technology and in market organization and practices, research is needed to help farmer cooperatives and other marketing agencies perform needed marketing services both more efficiently and more effectively. Farmer-directors, managers and others, including the public, need more information to assist in making decisions on how cooperatives can maintain and strengthen the bargaining power of farmers, increase efficiency and reduce costs of marketing, and better meet the needs of our mass distribution system for large quantities of products on a specification basis.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting farmers' marketing problems in our modern, dynamic system. They are organized and operated to increase farmers' net income. However, cooperatives face many problems in achieving this goal. Cooperatives must find ways to consolidate volume, for example, through internal growth, merger, acquisition or federation, to strengthen their market position and meet the needs of mass merchandising. Ways must be found to reduce costs by increasing efficiency through improved operating methods, better organization and management, and more use of new technologies.

### USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D. C. Many of the studies, however, are done in cooperation with various State Experiment Stations, Extension Services, and Departments of Agriculture.

The number of Federal professional man-years devoted to research in this area totals 21.2, of which 1.0 man-years are on the cooperative marketing of deciduous fruit.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Coordination of marketing. A study was initiated to determine organizational characteristics and operating methods of selected joint sales agencies which market fruits and vegetables for member associations, evaluate their problems and possibilities, and develop guides for other cooperatives interested in a coordinated marketing program.

Potentials in cooperative marketing. Work is underway to analyze the present status and trends in the cooperative marketing of fruits, vegetables and nuts, and to evaluate the potential of cooperatives for increasing their operating efficiency and market effectiveness through integration, coordination, consolidation, expansion or other means.

Cooperative bargaining. Work is being carried on to provide guides to growers and other segments of the processed fruit and vegetable industry in evaluating the potentials of this marketing method.

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ECONOMICS OF MARKETING  
Marketing Economics Division, ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economics of scale and efficiencies possible in the marketing of farm products.

Marketing research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective interregional shifts in the areas of production and marketing for specific products.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural economists, economists, and personnel with dual economic and technical training engaged in research to determine the reasons for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. This research covers all economic aspects of marketing from the time products leave the farm until they are purchased by ultimate consumers. It includes work on market potentials for new products and uses; merchandising and promotion; economics of transportation and storage; economics of product quality, marketing costs, margins and efficiency; market structure, practices and competition; and on information, outlook and rural development. In fiscal year 1963, 8.3 Federal professional man-years were utilized in this work on deciduous fruit and tree nuts.



## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Market Potentials for New Products and Uses

Deciduous Fruit. Research to further evaluate the potentials for super-concentrated apple and grape juices made through Eastern Utilization's essence recovery process is in the data collection phases. Work on dehydro-frozen apples was completed with the publication of a report of findings. A number of processing plants are now in operation and several grocery chains are using this form of apple in their pie-baking operations.

Merchandising and Promotion

Effect of Color in Consumer Acceptance of Red Delicious Apples. This research provides apple growers with information useful in appraising alternative grading and sorting practices. Through experiments conducted in retail food stores, consumer purchases were recorded for red delicious apples; 75 to 100 percent good red color, 50 to 75 percent, and 50 to 100 percent. No price differential was imposed. Sales from displays having 75 to 100 percent good red color were significantly higher than from either the 50 to 100 percent good red color or 50 to 75 percent displays. Despite a wide range in color, sales from the 50 to 100 percent good red color display were considerably higher than the less fully but more uniformly colored 50 to 75 percent good red color display.

Annotated Bibliography of Apple Marketing Research. Research related to the merchandising and promotion of apples conducted during the past 15 years has been reviewed and some of the most significant findings summarized. Also, research needs in this area are evaluated. This review is being included as a section of a report reviewing results covering a wide range of marketing research.

Merchandising and Promotion Techniques for Winter Pears. An evaluation has been completed of the effect of various promotional techniques on sales of winter pears. Store demonstrations and dealer contests were found to be equally effective in increasing sales. These techniques increased sales by 24 percent and 22 percent respectively, as compared to no promotion. Sales during periods of media advertising at a relatively low level of intensity and during periods of use of special point-of-purchase displays were not significantly different from sales during periods of no promotion. Support given by retailers to each promotional technique appeared to be an important factor influencing sales. The promotional techniques showing the greatest impact on sales were those which the retailer supported most in terms of more favorable consumers prices, greater display space, and featuring of winter pears as part of their newspaper advertising.

Evaluation of the Effect of Various Promotional Themes and Techniques on Sales of Fresh Peaches. A study has been initiated in cooperation with Washington State University to aid peach producers in expanding the market

for fresh peaches by providing information necessary for the efficient development and administration of their promotional programs. Specific objectives are to: Evaluate the relative effect on sales and demand for fresh peaches of selected promotional themes and techniques; determine the relationship of promotional outlay to sales returns for each theme or technique tested; and relate total promotion and advertising to the media advertising done by individual retailers.

Increased Produce Sales Through Improved Merchandising. Work has been started to review research conducted by the Department and other sources on retail merchandising and promotion of fresh produce. From this review, research findings applicable to improved retailing of produce will be condensed, assembled, and made available to retailers, commodity groups, and others involved in distribution of produce.

### Economics of Transportation and Storage

Fruit and Vegetable Transportation. The volume of fresh produce shipped interstate from California-Arizona production areas has remained relatively constant since 1951. Total traffic handled by both railroads and trucks has averaged about 350 thousand carlot equivalents annually. Approximately 60 percent of the interstate shipments from California-Arizona origins moves to destinations east of the Mississippi River. About 32 percent moves to points west of the River, while 8 percent is dispatched to Canada and Mexico. In 1951 rail carriers handled 87 percent of the shipments to United States outlets and 93 percent of the traffic routed to Mexican and Canadian destinations. Since then, rails' share of the annual volume shipped from California and Arizona to interstate markets has dropped to 70 percent and to 81 percent of the movement into Canada and Mexico during 1960. This loss by the railroads to trucks occurred primarily in that traffic moving to points west of the Mississippi River.

The ability of motortrucks to perform multiple pickup and multiple dropoff service, to make faster deliveries, and to offer greater flexibility for servicing less than truckload consignments were prime factors contributing to their success. Trucks are providing services that rails cannot duplicate economically.

### Economics of Product Quality

Feasibility of Radiation Pasteurization. The Atomic Energy Commission is interested in determining if radiation pasteurization of fresh strawberries, peaches, citrus fruits, grapes, and tomatoes is economically feasible. Preliminary results of this study indicate that under present marketing practices product losses in marketing channels are as high as 15 percent. Interviews with representative samples of packers, shippers, and retailers of these fruits indicate a definite desire for extension of shelf life of these products, possible through radiation pasteurization, and a willingness to accept such products. The marketing firms interviewed indicated that the major dis-



advantage of the process probably would be consumer resistance, but that this might be overcome through an educational program. Work is now in progress on the developments of estimates of the cost of radiation pasteurization to assist the AEC in developing designs for suitable equipment and facilities. This research is a part of the AEC program for expansion of the peaceful uses of the atomic energy.

### Marketing Costs, Margins and Efficiency

The Cost of Packing and Storing Michigan Apples. Changes are taking place rapidly in the marketing of apples. These changes include new containers, packing techniques, and the expanded use of controlled atmospheric storage. Needed adjustments to these changing marketing conditions require current information on the costs of packing and storing apples. Under this new project, economic engineering analyses are planned for a sample of Michigan packinghouses to develop detailed cost and equipment standards for packing and storage operations.

Marketing Margins. Marketing margins, retail prices, and farm values for fresh fruits and vegetables each increased 3 percent from 1961 to 1962. The farmer's share of the retail price for fruits and vegetables remained unchanged at 34 percent. Margins and prices for processed fruits and vegetables decreased. The farm value was down 12 percent, the retail price 4 percent, and the marketing margins 1 percent. The farmer's share of the retail cost dropped from 23 to 21 percent. A study of marketing margins for Washington Delicious Apples sold in Chicago and New York City showed the largest component to be the wholesale-retail margin. This margin claimed from 37 to 54 percent of the retail dollar in Chicago, and from 34 to 48 percent in New York City.

### Market Structure, Practices and Competition

Changes in Structure of Wholesale Fruit and Vegetable Markets. Direct buying of fresh fruits and vegetables from shipping points by retail chains, together with increased prepackaging, have had serious effects on the structure of the wholesale market for fresh produce.

A final report summarizing changes in the structure of 52 wholesale produce markets has been completed. Direct purchases from shipping point by chains and affiliated groups increased from 12 percent of total market receipts in 1936 to 26 percent by 1958. During this same period the number of produce wholesalers decreased by 15 percent.

There is a shift toward more specialized markets for fruits and vegetables as reflected by changes in the types of fruit being handled by auctions located in terminal markets and by the increase in consumer packaging. In addition, in the produce industry there is a shift in emphasis from "trading" to "merchandising." Many firms are giving emphasis to performing marketing services contributing to orderly marketing rather than attempting to profit from short-term changes in prices.



Changes in the Structure and Performance of the California Fruit and Vegetable Industry. Changes in the market structure and practices in marketing fruits and vegetables grown in California require producers, shippers and wholesalers to adopt lower cost methods and practices.

Particular attention has been given to an examination of the assembly and distribution of fresh fruits and vegetables including mode of transportation and composition of shipments. From 1955 to 1961 transportation of fresh fruits and vegetables shipped out of California by truck increased from 20 to 30 percent of the total volume. In 1961, shipments in mixed loads accounted for 65 percent of all trucks inspected at border stations--averaging 5.5 different commodities per load.

Competition in the Red Tart Cherry Industry. Tart cherry producers in the Great Lakes States have been faced with difficult marketing problems. Underlying these problems are a declining demand, a highly fluctuating supply with an upward trend, and resulting declining and unstable prices.

Price, production cost and processing cost analyses, and a study of the implications of the European Common Market to fruit and vegetable industries have been made. The price analysis showed that a supply change of one-tenth pound per capita (raw product weight) was associated with an opposite direction price change of 50 cents per hundred pounds of tart

cherries (processed). The trend of tart cherry prices since 1947 has been down. Production cost analyses in Michigan, New York, and Pennsylvania indicate a wider divergence of costs within producing areas than between areas. The major producing State, Michigan, does not appear to have a production cost advantage. Estimates of processing costs have been made by plant stage. A new mechanical sorting machine is shown to be cost reducing only in plants operating for unusually long seasons. While the European Common Market is expected to decrease its imports of our farm products, the effect on tart cherries will be relatively small because these countries have taken few tart cherries in the past.

Organization of the California Deciduous Fruit Industry. Technological changes in marketing practices affect the structure and performance of the fresh produce industry and the competitive position of major producing areas. Technological changes are being adapted rapidly because of the large amount of labor required in handling and packing.

A research team composed of pomologists, physiologists, engineers, and economists is studying various methods of packing peaches, nectarines, and cantaloups from the standpoint of relative costs and quality. Indications are that cost savings with a "tight-fill" pack compared to the conventional place pack amount to as much as 15 cents per lug. Savings in labor alone were estimated to be 10 cents per lug. With savings of this magnitude, efficient plants could be modified with tight-fill equipment and have a "pay off" period of less than one marketing season.

From the quality standpoint, laboratory tests and trial shipments show that the tight-fill pack is equal to or better than the conventional place pack on arrival at market destination.

Variations in Apple Prices. Variable apple crop size from year to year and technological and economic developments are having serious impacts on apple marketing. Rational allocation of apples between fresh and processed markets and through the shipping season requires reliable information regarding prices and price elasticities.

The U. S. season average farm price of canning and freezing apples can be estimated by using data which are available early in the marketing season. Information on crop estimate, processed stocks, farm price of fresh apples, and a trend variable explained more than 90 percent of the variation in deflated farm prices of processing apples from 1951 to 1961. The demand for all apples sold from July to November, the harvest period, was inelastic. The results suggest that demand for fresh apples is slightly more inelastic than the demand for processing apples during this period. Fresh apple sales, lagged fresh price, sales of competing fruits, and income accounted for 92 and 84 percent of the variation in fresh apple prices in the periods of December to March and April to June, respectively. Demand was slightly inelastic in the December to March period, but slightly elastic in the April to June period.

Marketing Pecans. The pecan industry has been hampered by lack of knowledge concerning the structure of the industry, annual supplies and prices, the competitive position of pecans relative to other tree nuts, and data for planning by the industry.

Increases in pecan production were greater than population increases until the late 1940's, paralleled population growth until the mid-1950's, and have increased more slowly than population since then. Production is expected to increase at less than the population rate until about 1971, then increase more sharply. It is estimated that the price elasticity of demand for pecans is approximately -1.4. Thus, with a strong demand for pecans and other edible tree nuts, and little change in per capita supplies of pecans over the next decade, combined with a likely increase in consumer income, the outlook for pecan prices (and the pecan industry) is good.

A study of the pecan nursery industry disclosed that sales of pecan trees doubled between 1958 and 1962. The tremendous increase in the number of pecan trees propagated, assures a greater expansion of pecan production in the years ahead than had been calculated from time-series data. It is also indicated that a larger proportion of the total crop will come from improved varieties, now about 50 percent of the total.

## Information, Outlook and Rural Development

### First Phase of Long-Term Outlook for Marketing Western Agricultural Products Relates to Fruits and Vegetables

Outlook for the marketing of fruits and vegetables for the 11 Western States was projected for the period 1975. These projections show a continued growth in the volume of these products and indicate that this western region should supply an increasing share of the total. The forecast is based on an expected increase of 31 percent in total U.S. population and some increase in per capita consumption per year. The West now supplies about 65 percent of noncitrus fruit, 45 percent of vegetables, and 28 percent of citrus fruits. Increases in the proportion of total supply of noncitrus fruits and vegetables, with a small decrease in the proportionate citrus fruits supplied by the West, appear in prospect. These changes can be viewed in terms of the total U.S. consumption increase projected for the period of approximately 33 percent above that of 1960.

The greatest growth including vegetable sales appears to be in processed products. The greatest growth in food and vegetable processing between now and 1975 is likely to be in freezing, combined freezing and dehydration, and various improved methods of dehydration. In these areas processing has grown rapidly and is likely to continue to grow for the next several years, though possibly at a slower rate.

### Long-Term Outlook for Industries Assembling and Processing Products of Agriculture in the Pacific Northwest

This research, by five-year periods between 1965 and 1980, will project the production and employment in establishments assembling and manufacturing products of agriculture. The geographical area covered will include the States of Washington, Oregon, Idaho, and western Montana. Projections for the statistical base period (1965) are near completion. During the coming year extensive progress is anticipated in completing the series of five-year projections.



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**ECONOMIC AND STATISTICAL ANALYSIS**  
**Economic and Statistical Analysis Division, ERS**

Problem. Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for sound production and marketing decisions. It has long been a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting the principal farm commodities.

Producers, processors, distributors and consumers need better information on supplies, production and consumption of farm products, and the effect of these and other factors on the prices of these products. Similarly, Congress and the administrators of farm programs need to evaluate alternative proposals to modify existing price support and production control programs in terms of their impact on production, consumption and prices received by farmers.

**USDA PROGRAM**

**Commodity Situation and Outlook Analysis**

This work involves 0.5 professional man-year in Washington. The outlook and situation program involves a continuing appraisal of the current and prospective economic situation for deciduous fruits and tree nuts. Results of these appraisals, findings of special studies, and long-time series of basic data are published in the Fruit Situation, issued 4 times a year, and in brief reviews in quarterly issues of the National Food Situation and the Demand and Price Situation, and monthly in the Farm Index. A comprehensive analysis of the deciduous fruits and tree nuts situation is presented at the Annual Outlook Conference. Outlook presentations also are made at regional and State outlook meetings, meetings of farm organizations, and to various agricultural industry groups. Special studies are made from time to time to determine probable effect of proposed programs on supply, price and consumption of these commodities. Basic statistical series on stocks, foreign trade, consumption, and price are compiled, improved and maintained for general use in statistical and economic analysis.

## Supply, Demand and Price Analysis

This work involves 0.5 professional man-year located in Washington, D. C. The current emphasis is on demand and price analysis for peaches. The study includes analyses which measure statistically the influence on prices of available supplies of different types of peaches, consumer income, supplies of competing products, and the carryover stocks from the previous season. An attempt is being made to find statistical techniques which allow for the joint interaction among prices and different end uses such as fresh market, canning, drying, and freezing. Because of the substantial changes in utilization trends in recent years, these interactions are difficult to measure.

### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

#### Commodity Situation and Outlook Analysis

The 1962 deciduous fruit crop was about 1 percent larger than in 1961 and 6 percent above the 1957-61 average. Mainly because of widespread unfavorable early-season weather, the 1963 crop is expected to total about 3 percent below 1962, although 3 percent above average. All major fruit crops are expected to be down from 1962 except apricots, grapes, nectarines, and plums.

Total production of edible tree nuts in 1962 was 36 percent below the heavy 1961 tonnage and 23 percent under the 1957-61 average, mainly due to a light pecan crop. But with prospective sharp increases in pecans and almonds, the 1963 tree nut crop is expected to set a new record, 73 percent above last year and 33 percent above average.

Prices received by growers for 1962 crops were above 1961 for apples, grapes, and apricots, but below for peaches, pears, and cherries. Prices to growers for the 1963 crops generally should equal or exceed those of 1962.

In 1962 as in 1961, processing outlets took about 59 percent of deciduous fruit production. The 1962 canned pack was record large, but output of frozen fruit (excluding juice), and dried fruit was down. Although heavy packs of canned peaches, fruit cocktail, and applesauce are expected in 1963, the total canned pack probably will fall moderately below 1962. The pack of frozen fruit also is expected to be down, but dried fruit up.

Substantial increases in U.S. exports of canned peaches and fruit cocktail, from record packs, highlighted foreign trade in noncitrus fruits in 1962-63. Exports of canned pineapples also were up considerably, fresh pears up a little, and dried prunes not greatly different from 1961-62. But exports of apples (fresh) and raisins were down sharply.

A study of trends in pear production and use since 1935 disclosed:

(a) Increased concentration of production in the Pacific Coast States about offset by decreases in other States; (b) a marked shift in emphasis from fresh to processed, especially canning, in use of pears sold; and (c) a small decrease in total consumption of pears, but a larger decrease in per capita use.

New indexes of production and prices for noncitrus fruits, beginning 1935, were included in the June 1963 issue of the Fruit Situation. Similar indexes for edible tree nuts were published in the August issue. The new indexes (1957-59=100) replace old indexes (1935-39=100). Long-run projections (5 years) were developed for deciduous fruit as part of a set of ERS projections for the economy as a whole.

An article, prepared in the Marketing Economics Division of Economic Research Service, evaluated survey data relating to fruit consumption under the food stamp program conducted in Detroit, Michigan, and rural Fayette County, Pennsylvania, in 1961. It showed that total consumption of all fruit and fruit juices (fresh fruit equivalent basis) by families using food coupons increased over previous consumption.

#### Supply, Demand and Price Analysis

Peaches. Work during the current reporting period included additional analysis on factors affecting grower prices for Clingstone peaches for canning during the postwar years. A number of formulations, including different measures of packer carryover stocks, production or expected production, in addition to income, as economic variables affecting prices were tried. The statistical results were not rewarding. Only a little more than half of the Clingstone price variation could be explained by these factors when allowance was made for changes in the price level and population growth.

Apples. A summary of apple demand and price analyses published from 1945 through 1960 was made as part of a comprehensive study on what is known about apple production and marketing to be released in October. This report includes work done outside as well as work within the Department. The contents of this report were summarized in the previous reporting period. Because of the growing importance of canning in recent years, the study recommends the need of more studies relating to demand interrelationships for processed products and fresh market. In addition the study found very little research on the long-term prospects for demand and supply for apples.

### **PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH**

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CONSUMER PREFERENCE AND QUALITY DISCRIMINATION--  
HOUSEHOLD AND INDUSTRIAL  
Standards and Research Division, SRS

Problem. With the increasing complexity of marketing channels and methods, it has become almost impossible for the consumer to express to producers either his pleasure or displeasure with available merchandise. In order to market agricultural products more efficiently, we need to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on preferences, levels of information or misinformation, and satisfactions or dislikes of both present and potential consumers. We also need to know consumer attitudes toward the old and new product forms of agricultural commodities and their competitors, and probable trends in the consumption of farm products. We need to know the relationship between agricultural and nonagricultural products and the relationship of one agricultural commodity to another in consumers' patterns of use. Producer and industry groups and marketing agencies consider this information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increase returns to growers.

USDA PROGRAM

The Special Surveys Branch of the Standards and Research Division conducts applied research on representative samples of industrial, institutional, or household consumers and potential consumers, in local, regional, or national marketing areas. Such research may be conducted to determine: attitudes, preferences, buying practices, and use habits with respect to various agricultural commodities and their specific attributes; the role of competitive products, and acceptance of new or improved products.

The Special Surveys Branch also conducts laboratory and field experiments in sensory discrimination of different qualities of a product. These studies ordinarily relate discrimination to preferences and attitudes as they influence purchases in order to assess the standards of quality, packaging, etc., which are needed to satisfy consumer demands.

The work of the Branch is carried out in cooperation with other Federal governmental agencies, divisions within the Department of Agriculture, State Experiment Stations, Departments of Agriculture, and land grant colleges, agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff, with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology and other social sciences, in Washington, D. C., which is headquarters for all of the survey work whether it is conducted under contract or directly by the Branch.

The Federal scientific effort devoted to research in this area during the past year totaled 7.0 professional man-years, of which 0.4 was devoted to work on deciduous fruit.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### Consumer Preference

Preliminary planning has been completed and a pretest questionnaire drafted for this nationwide study covering the patterns and frequency of use of selected noncitrus fruits in the home as well as attitudes and opinions which influence use or nonuse of the fruits. Principal emphasis of the questioning is on fresh fruits in general and on apples, the volume leader among noncitrus fruits, in particular, but questions about certain other fresh noncitrus fruits will be included in the questionnaire under terms of the contract signed last year with a private research firm. Some data about processed fruits will also be sought.

The final report on a study to determine consumer acceptance, on a commercial trial basis, of a superconcentrated apple juice developed by the Eastern Utilization Research and Development Division of the Agricultural Research Service was published in January 1963. Data from this study, which was conducted in cooperation with Economic Research Service, have been discussed in previous progress reports.

Winter pears. Exploratory work was carried out on a study designed to assist producers of winter pears in increasing the sales of their products on the fresh market. Since most varieties of winter pears are not particularly suitable for processing, the strengthening of the fresh market for these fruits is especially important to the growers. A pretest questionnaire was designed to explore household buying and usage patterns for winter pears, with particular emphasis on consumer interest in retail availability of ripe fruit.

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Consumer Preference

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IMPROVEMENT OF CROP ESTIMATING PROCEDURES  
Standards and Research Division, SRS

Problem. The Statistical Reporting Service produces a large number of current statistics pertaining to agriculture. Because of limited resources, statistical methods were devised with a view to producing the most information for the least cost. These methods are subjective in nature and are based largely upon self-selected samples from voluntary crop reporters who fill out and return mailed questionnaires. The information is generally collected in the form of relatives such as acres this year compared to last, the crop condition as a percentage of full crop. Persistent bias is removed by charting and census or other check data are generally projected to form current estimates. Estimates based on these sample methods have proved relatively satisfactory over the years. However, in seasons when changes are unusually large the changes may not be fully reflected in the appraisals and reports of the respondents to mailed questionnaires. In situations like this, when accuracy is needed most, the estimates may lack the required precision. Then, when the estimates are translated into available supplies for the different commodities, price inequities may occur and, as a result, producers or the processors of agricultural commodities may suffer serious financial loss.

USDA PROGRAM

The Department of Agriculture conducts a program of applied research designed to strengthen and improve the methodology used in collecting agricultural statistics. The principal disciplines involved are mathematics, statistics and probability, but other disciplines relating to a particular problem are brought to bear as required. Examples of these are plant physiology, psychology, cartography and photogrammetry. The current program consists of 6.0 professional man-years per year devoted to the study of sample and survey methods, and 4.0 professional man-years working on methods for forecasting and estimating the yields of important crops. Work under this program is done in Washington, D. C., and in SRS field offices located in the States concerned.

Objective forecasting procedures are being developed for sour cherries and grapes; 1.0 Federal professional man-year is being utilized.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

In 1962 objective sampling of sour cherries was extended to include 20 sample orchards in each of New York, Pennsylvania, and Wisconsin, in addition to the 180 orchards in Michigan. This extension was made possible by a grant in funds from the Cherry Producers Marketing Cooperative, Inc., of Grand Rapids, Michigan, in the interest of developing objective methods which would forecast over 98 percent of the sour cherry production in the Great Lakes Region. In each State, studies were made in two phases, the first a series of four sample surveys conducted over the season on a probability sample of orchards

to estimate fruit numbers per tree and weight per cherry as of average survey date. Coefficients of variation for averages of fruit per tree were about 8 percent in Michigan and about twice as large in the other three States where samples were much smaller. Coefficients of variation for average weight per fruit were approximately 2 percent in Michigan and 5 percent in the other States.

The second phase of the sampling investigations was a development study based upon frequent visits of 5 or 6 orchards in each State. Observations were made on bloom development and pit hardening, and to determine the rates of fruit droppage and weight development. Date of hardening is closely related to date of bloom and is a desirable indicator of relative maturity which occurs later in the growing season than bloom. However, pit hardness is much more difficult to measure objectively and will require continued research to develop measurement techniques and to establish a series of data. Parameter curves have been developed for predicting mature fruit numbers and weight per cherry by combining data from the yield and development phases of the cherry project. For the June 15 forecast, these parameters are used to project for the remaining 18 to 45 days until harvest. The June 15 survey averages represent 107-209 percent of actual numbers of fruit at harvest and as little as 7 percent of the harvest weight per fruit.

These parameters were developed for the three districts in Michigan to permit a differentiation between early and late districts. Pennsylvania parameters are similar to the earliest Michigan district; likewise Wisconsin is more nearly like the latest district in Michigan but these similarities would need to be verified over years.

Plans to continue in 1963 with investigative sample surveys in New York, Pennsylvania, and Wisconsin were abandoned because industry funds were not again supplied for this work.

The Michigan sampling program was revised to incorporate one additional survey visit in early June. This survey, in one-fourth of the sample orchards, provided an estimate of the fruit droppage rate for the period just preceding the June 15 forecasting survey. This estimate of relative drop rate was applied to the droppage parameter curves to derive an estimate of days past bloom on a biological rather than a time basis.

In the development study, observations of pit hardening were made more objective by using scales to measure cutting pressure.

In both 1962 and 1963, Michigan data for June 15 and July 1 were used to calculate experimental forecasts which proved to be effective estimators.

Development studies have been conducted in Michigan in three vineyards each year beginning in 1960. Visits have been made twice monthly from July 1 until harvest to make counts of clusters per vine and weight and number of berries per cluster. Also in 1962 a pre-harvest survey of 25 sample vineyards was used to provide data of greater precision on variability and useful relationships.

Early counts of clusters can be used to forecast numbers at harvest time. Ratio of clusters maturing to clusters formed is very high with low variability between years. These relationships are nearly the same for numbers of berries per cluster, a property of special significance because of the very high within-year correlations between berries per cluster and cluster weight. The limited data of this development work demonstrates that this relationship is quite good between years, but not constant. Continued analysis and added data will establish the worth of early berry counts in forecasting bunch weight. Also, the use of an estimated biological reference date, such as date that berries attain some minimum weight, will be evaluated as to effectiveness in utilizing berry counts.

The 1963 series is being conducted on the same basis as previously, but with vines sampled in a different cluster configuration to determine relative efficiencies of alternative vine selection systems.





